IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

ETHANOL BOOSTING SYSTEMS, LLC and MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Plaintiffs, v. FORD MOTOR COMPANY, Defendant.	C.A. No. 19-cv-196-CFC-SRF **JURY TRIAL DEMANDED**

PLAINTIFFS' OPENING CLAIM CONSTRUCTION BRIEF

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I. Background

A. The Patents

Plaintiffs have asserted four patents in this action: U.S. Patent No. 8,069,839 ('839), U.S. Patent No. 9,255,519 ('519), U.S. Patent No. 9,810,166 ('166), and U.S. Patent No. 10,138,826 ('826). Each of these patents continues from, and claims priority to, U.S. Patent Application No. 10/991,774 (the "Application"), which was filed November 18, 2004. Apart from the recitations concerning each patent's chain of priority, each patent's specification is identical to the original Application. As such, for the Court's convenience, Plaintiffs cite to the Application (attached as Exhibit 1) rather than the individual specifications.

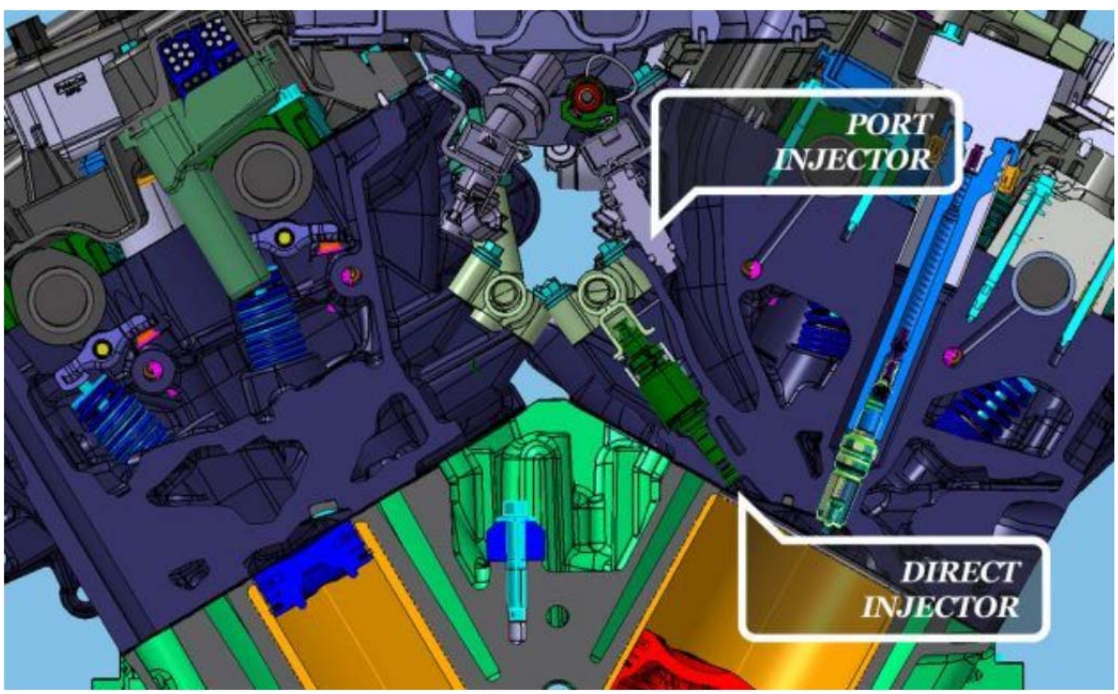
The asserted patents are the brainchild of three remarkable men: Dr. Leslie Bromberg, Dr. Daniel Cohn, and Prof. John Heywood. Each has spent much of their lives working with and improving engines—including more than ten decades combined at MIT.

Prof. Heywood, for example, was the Director of the Sloan Automotive Laboratory at MIT and literally wrote the textbook on the internal combustion engine. Since 1988, his *Internal Combustion Engine Fundamentals* ("*ICEF*") textbook has been used by engineers the world over as a primer on the operation of internal combustion engines like those to which the patents are directed. Dr.

Bromberg and Dr. Cohn likewise are both internationally known for their work on improved engine technologies—each having received more than 80 granted patents.

The asserted patents build on this experience. Each patent claims spark ignition internal combustion engines, and fuel management systems, that improve over the prior art by disclosing new combinations of two different fuel injection techniques: (1) port fuel injection ("PFI"), in which fuel is injected into an intake port, and (2) direct injection ("DI"), in which fuel is injected directly into the engine cylinder. Ex. 1 at 4:16-27, 6:5-8.

An exemplary depiction of such a "dual injection" engine—including the location of such injectors—is shown below.



Ex. 11 at 1.

As the specification common to each patent explains, the incorporation of such dual injection technology was groundbreaking. Among other benefits, it allows an engine to continue to benefit from the better "air/fuel mixing and combustion stability" associated with port fuel injection, while also reaping the benefit of a phenomenon known as "cylinder charge cooling." Ex. 1 at 5:5-8, 5:23-27.

The specification explains that "[d]irect injection of gasoline results in approximately a five octane number decrease in the octane number required by the engine" and a "30K drop in charge temperature." *Id.* at 6:5-8. The cylinder charge cooling resulting from such direct injection allows an engine to better avoid "engine knock," which is "the undesired detonation of fuel [that] can severely damage an engine."[1] *Id*. at 2:12-16.

In addition, the patents go beyond describing new combinations of direct and port fuel injection. They also include embodiments that use closed and/or open loop control (described in more detail below) to dynamically vary when and how each fuel system is used. *E.g.*, *id*. at 3:18-25, 4:16-27.

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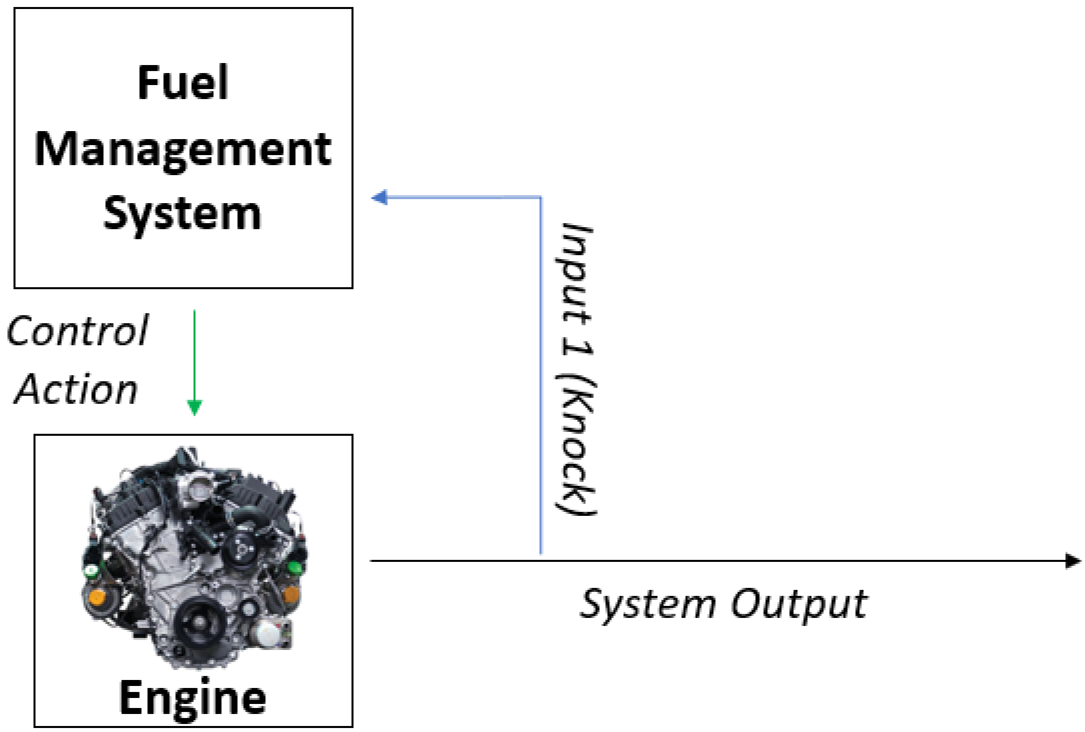
[1] As Ford has acknowledged, "knock" typically is detected by a "knock sensor [that] 'monitors structure-borne noise, which it transforms into an electrical signal suitable for transmission to the ECU [engine control unit].'" Ex. 8 ('839 IPR Petition) at 52.

B. Common Principles/Concepts

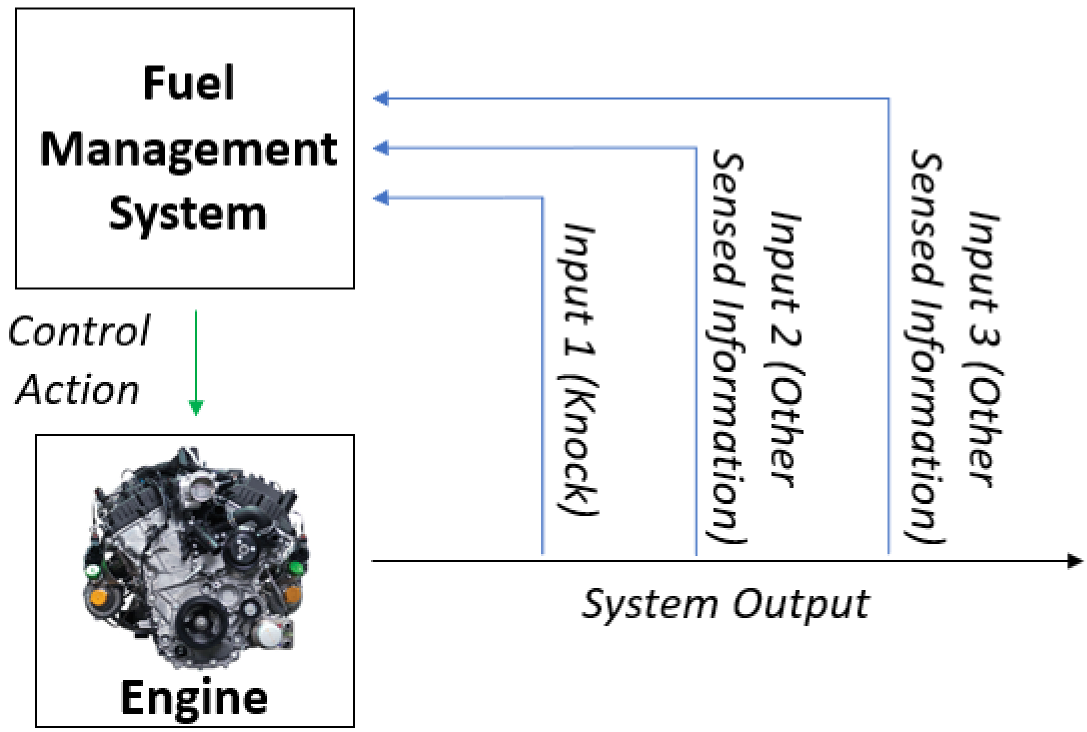
Three concepts are repeated throughout the patents. The first is the concept of direct and port fuel injection depicted above. The parties agree that direct injection means "direct injection of fuel into a cylinder" and port fuel injection means "injection of fuel into an intake port or intake manifold." Joint Chart, D.I. 67 at 2-3.

The second concept—"torque ranges"—is closely related. The terms first torque range and second torque range are used throughout the patents as a shorthand reference for which fueling system is being used. When direct injection is being used, the engine is in the first torque range; when direct injection is not being used, the engine is in the second torque range. *See*, *e.g.*, Ex. 9 ('166 IPR Petition) at 3 ("The terms 'torque range,' 'range of torque,' and 'region of torque' ('torque range') are used throughout the challenged claims to define at least a first torque range whereby an engine uses port fuel injection ('PI') **and** DI, and a second torque range where PI **alone** is used." (emphases added)).

Finally, the specification and asserted claims also contemplate various control systems and mechanisms, including various implementations of what is known as "closed loop control," which the parties agree is a feedback-based control system. Joint Chart, D.I. 67 at 8-9. As Plaintiffs' expert Dr. Gregory Shaver explains, closed loop control involves monitoring a system (like an engine) for one or more controlled outputs and then relaying those outputs (i.e., feedback) back to the system, which uses them to affect the control actions it takes. Ex. 10 (Shaver Decl.) at ¶¶ 9-10. A simple example of such a closed-loop system (in this example, a knock-control system) is depicted below:



The patents also contemplate more sophisticated embodiments, including those in which—as depicted below—multiple inputs may be received:



Cf. Ex. 3 at 7:53-57 ('519 Claim 5) (stating that "sensed information" can be received by "the fuel management system" and that "both the sensed information and information about knock are used to control the fuel that is introduced by the first fueling system"); *id*. at 8:24-26 (Claim 13).

II. Disputed Claim Constructions

A. "torque" ['839 (Claims 1-2, 7-8), '519 (Claims 1, 3-4, 6, 10-11, 15, 18-20, 22, 26, 29), '166 (Claims 1-4, 7-8, 10, 14-16, 19-21, 23, 26-28), '826 (Claim 1-8, 10-15, 20-24, 29-33)]

Plaintiffs' Construction:	Ford's Construction:
Plain and ordinary (no construction needed). Alternatively, if construed, "measure of a turning or rotating force on an object."	"Torque is the measure of a turning or rotational force on an object. Torque is calculated by multiplying force and distance. It is a vector quantity, meaning it has both a direction and a magnitude."

The term "torque" does not require construction. As Prof. Shaver explains, a POSITA would have no trouble understanding the term. Ex. 10 (Shaver Decl.) at ¶ 11.

The same is true of any juror. As demonstrated by the below screenshots, Ford uses the term "torque" in advertisements to the general public, including on its website, without the need for further explanation:

3.5L ECOBOOST®

375 horsepower and best-in-class* 470 lb.-ft of gas torque.

*When properly configured. Class is Full-Size Pickups under 8,500 lbs. GVWR.

Ex. 12 at 4.

Ex. 13 at 1 (also available at https://www.youtube.com/watch?v=QEFlQSCLEIo). A more technical understanding is not necessary for this case.

If the Court does construe the term, however, for two reasons it should adopt Plaintiffs' construction, which duplicates the first sentence of Ford's construction but omits the remainder.

First, Ford's proposed construction explains how to calculate torque, but none of the claims require a calculation of torque. As a result, the jurors do not need to know how to calculate torque and including that information in the construction needlessly complicates it and could potentially confuse the jury.

Ford's statement about how to calculate torque also is misleading because it provides only one of the many ways to calculate torque. Ex. 10 (Shaver Decl.) at ¶ 12. Including only one method of calculating torque and omitting the other methods would mislead the jury because it suggests that Ford's method is the only way to calculate torque, which is not correct.

Second, Ford's construction further complicates the term by adding a third sentence that simply restates in a more complicated mathematical fashion what already is stated: that torque is a "measure of a turning or rotating force on an object." That sentence is not needed and is confusing.

For the reasons set forth above, the Court should construe this term to have its plain and ordinary meaning or, at most, to mean "measure of a turning or rotating force on an object."

B. "torque range" ['519 (Claims 19, 20, 22), '166 (Claims 1, 10, 14-16, 20, 28, 29), '826 (Claims 1-15, 20-25, 28-33)] / **"range of torque"** ['519 (Claims 1, 4), '166 (Claims 7-8, 19)]

Plaintiffs' Construction:	Ford's Construction:
Plain and ordinary (no construction needed). Alternatively, if construed, "range of torque values from one value of torque to another value of torque."	"a range of torque values from one specific value of torque to another specific value of torque"

These terms also do not require construction. The word "torque" is addressed separately above at pages 7-10. The term "range" does not need to be construed as demonstrated by the fact that both parties use the term "range" in their proposed constructions. A POSITA and the jury will both understand the word "range."

Nevertheless, if the Court does construe these terms, the parties' dispute is narrow: whether the terms should be construed to mean "range of torque values from one specific value of torque to another specific value of torque" as Ford argues or whether the word "specific" is simply Ford's attempt to narrow the claim by importing a limitation not found in the specification or claim language. Plaintiffs' position is the correct one.

The word "specific" does not appear in the claims or the specification. For this reason alone, it is improper to import that limitation into the claim language. *In-Depth Test LLC v. Maxim Integrated Prods., Inc.*, 2018 WL 5669165, at *2 (D. Del. Nov. 1, 2018) (Connolly, J.) (rejecting defendant's construction—explaining that, "'[w]here a specification [i.e., written description] does not require a limitation, that limitation should not be read from the specification into the claims'" (alteration in original) (quoting *Specialty Composites v. Cabot Corp.*, 845 F.2d 981, 987 (Fed. Cir. 1988))).

Further, Ford has no support for adding that limitation, and it has not explained its basis for doing so. It appears that Ford is attempting to introduce the requirement that the relevant "value[s] of torque" are inflexible—i.e., that they must be pre-determined or fixed. That is wrong and squarely conflicts with the claims, which make clear that the relevant torque ranges may change.

As explained above, the patents use the terms "first torque range" and "second torque range" to refer to the ranges in which each fueling system is used. *See*, *e.g.*, Ex. 9 ('166 IPR Petition) at 3. And the patents demonstrate that, at least in some embodiments, the fueling system(s) used at a particular value of torque can change. For example, Claim 27 of the '519 Patent claims a "fuel management system [that] uses information from a sensed parameter to control spark retard so as to decrease the amount of fuel that would otherwise be provided by the first fueling system … to zero." Ex. 3 at 9:10-24, 10:9-11. In other words, it recites a fuel management system that uses information from a sensed parameter to change the values at which the engine otherwise would enter the "first torque range." This variability of torque range present in Claim 27 (and many other claims) demonstrates why Ford's attempt to add "specific" into the claim is inappropriate.

In sum, because Ford's "specific" limitation is not required—and is inconsistent with the claims—it should be rejected. *IPC Sys., Inc. v. Cloud9 Techs. LLC*, 2018 WL 5342654, at *4 (D. Del. Oct. 29, 2018) (Connolly, J.) (rejecting construction inconsistent with the claims (quoting *Phillips v. AWH Corp.*, 415 F.3d 1303, 1314 (Fed. Cir. 2005))).

C. **“above a selected torque value the ratio of fuel that is directly injected to fuel that is port injected increases”** [’839 (Claim 1)]

Plaintiffs’ Construction:	**Ford’s Construction:**
Plain and ordinary (no construction needed).	“above a selected torque value the ratio of fuel that is directly injected to fuel that is port injected is always increasing”

The parties’ dispute is simple. Plaintiffs ask the Court to reject Ford’s attempt to rewrite the claims by changing “increases” to “is always increasing.”

Ford’s “always increasing” construction is incorrect for a number of independent reasons. Primarily, it ignores the settled principle that claim construction should not be used to “rewrite claims.” *K-2 Corp. v. Salomon S.A.*, 191 F.3d 1356, 1364 (Fed. Cir. 1999) (“Courts do not rewrite claims; instead, we give effect to the terms chosen by the patentee.”).

Because neither the claims nor the specification even use the word “always”—much less require that fuel be “always increasing”—it is improper to add that limitation to the claims. *See Thorner v. Sony Computer Entm’t Am. LLC*, 669 F.3d 1362, 1366 (Fed. Cir. 2012) (“We do not read limitations from the specification into claims; we do not redefine words.”); *Intellectual Ventures I LLC v. AT&T Mobility LLC*, 2015 WL 1393386, at *15 (D. Del. Mar. 24, 2015), *aff’d sub nom.* 748 Fed. App’x 330 (Fed. Cir. 2019) (rejecting construction that “adds words to the original limitation with a net result of changing [its] meaning”).

Ford's "always increasing" construction also should be rejected because it contradicts the '839 Patent, which states that "[a]n object of the present invention is to minimize the amount" of directly injected fuel, Ex. 1 at 2:30-3:5, and allows for the possibility of a single increase—not always increasing. For example, Claim 1 states:

> 1. A spark ignition engine that is fueled both by direct injection and by port injection wherein above **a** selected torque value the ratio of fuel that is directly injected to fuel that is port injected increases; and wherein the engine is operated at a substantially stoichiometric fuel/air ratio.

Ex. 2 at 7:7-11 (emphasis added). Applying ordinary claim construction principles under which "a" means "one or more," this language contemplates that there may be a single torque value at which the ratio of directly injected fuel increases. *Baldwin Graphic Sys., Inc. v. Siebert, Inc.*, 512 F.3d 1338, 1342 (Fed. Cir. 2008) ("That 'a' or 'an' can mean 'one or more' is best described as a rule, rather than merely as a presumption or even a convention."). Ford's construction would incorrectly exclude the possibility of this single increase—requiring that there be multiple torque values at which the ratio of directly injected fuel increases because it "is always increasing."

Ford's construction also renders superfluous certain elements added in Claim 1's dependent claims. Claim 2, for example, recites "[t]he spark ignition engine of claim 1 where the ratio of directly injected fuel to port injected fuel increases with increasing torque." Ex. 2 at 7:12-14 (emphasis added). Under Ford's construction, this language would be entirely superfluous given that Claim 1 already would require the ratio of directly injected fuel to be "always increasing."[2] *In-Depth Test*, 2018 WL 5669165, at *3 (rejecting construction that rendered aspects of dependent claims "superfluous").

Other dependent claims further show that the patent does not require the fraction of direct injection fueling to be "always increasing"; rather, whether it increases depends on other factors. For example, Claims 3-5 state that the ratio of directly injected fuel is determined using, e.g., a "signal from a knock detector" (Claims 3 and 4) and/or "open loop control" (Claim 5). Ex. 2 at 7:15-24. In short, these claims contemplate a more sophisticated and dynamic system than Ford's simplistic "always increasing" limitation permits. *In-Depth Test*, 2018 WL 5669165, at *3 (applying "doctrine of claim differentiation" to reject the defendant's construction—explaining that "[t]he doctrine instructs that 'the presence of a dependent claim that adds a particular limitation raises a presumption that the limitation in question is not found in the independent claim'" (quoting *Liebel-Flarsheim Co. v. Medrad, Inc.*, 358 F.3d 898, 910 (Fed. Cir. 2004))).

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[2] To be clear, Plaintiffs do not contend that Claim 2 should be construed to require that the ratio of directly inject fuel be "always increasing." Claim 2 simply narrows Claim 1 to require that there be more than "one" increase.

Because Ford's construction attempts to rewrite the plain text of Claim 1 of the '839 Patent—and does so in a manner contradicted by the claims themselves—the Court should reject it.

D. "decreases with decreasing torque" ['519 (Claim 1)]

Plaintiffs' Construction:	Ford's Construction:
Plain and ordinary (no construction needed).	"always decreasing with decreasing torque"

Ford also asks the Court to rewrite the language of this claim—this time replacing the word "decreases" with the words "always decreasing." The Court should reject that request as well.

The term "always" is not present in either the claim language or the specification, and it is improper to add this limitation to the claim. *See K-2*, 191 F.3d at 1364 ("Courts do not rewrite claims ...."); *Thorner*, 669 F.3d at 1366.

Further, Ford's construction conflicts with the claims, which state that the fraction of fuel provided by the first fueling system does not always decrease with decreasing torque but—at a minimum—can stay the same. For example, dependent Claims 4 and 9 make clear that there is a "range of torque in which only the second fueling system is used" (Claim 4) and that this "range of torque" can occur at lower torque values than the range of torque in which "both the first and second fueling system are used" (Claim 9). Ex. 3 at 7:25-8:3.

In other words, these claims require that, in this embodiment, the fraction of fuel introduced by the first fueling system already have reached zero at the top of the second torque range. Logically then, the fraction of fuel introduced cannot continue to decrease (as would be required to be "always decreasing") as torque continues to decrease through the second torque range. *See Power Integrations, Inc. v. Fairchild Semiconductor Int'l, Inc.*, 904 F.3d 965, 972 (Fed. Cir. 2018) (explaining that, where both an operable and a non-operable construction are possible, "the inoperable construction is wrong" (citation omitted)).

Because Ford's construction seeks to rewrite the relevant claim in a manner that would render multiple dependent claims superfluous and inoperable, it should be rejected. *Id.*; *In-Depth Test*, 2018 WL 5669165, at *3 (rejecting "interpretations that render some portion of the claim language superfluous").

E. "fuel that is directly injected" ['839 (Claim 1)] / **"directly injected fuel"** ['839 (Claims 2-5)] / **"fuel provided by direct injection"** ['166 (Claims 5, 16, 27, 28)] / **"fueling that is provided by the first fueling system"** ['826 (Claims 3-8)] / **"fueling from the first fueling system"** ['166 (Claim 10)] / **"fuel provided by the first fueling system"** ['826 (Claims 13-15)]

Plaintiffs' Construction:	Ford's Construction:
Plain and ordinary (no construction needed). Alternatively, if construed, "fuel that is directly injected into a cylinder."	"a fuel that contains an anti-knock agent that is not gasoline, and that is different from the fuel used for port injection/in the second fueling system"

"fuel is provided by a first fueling system" ['826 (Claim 31)]

Plaintiffs' Construction:	Ford's Construction:
Plain and ordinary (no construction needed). Alternatively, if construed, "fuel is provided by a first fueling system using direct injection."	"a fuel that contains an anti-knock agent that is not gasoline, and that is different from the fuel used for port injection/in the second fueling system"

As an initial matter, there is no need to construe these terms. The term "fuel" is common and well understood.

To the extent the Court construes the term, however, the parties' dispute is simple: to avoid infringement of its gasoline engines, Ford asks the Court to rewrite each claim to preclude the use of gasoline as a directly injected fuel. No support exists for such a limitation. To the contrary, the specification expressly discloses that gasoline can be directly injected—explaining that "[d]irect injection of gasoline results in approximately a five octane number decrease in the octane number required by the engine, as discussed by Stokes, et al." Ex. 1 at 6:5-7 (emphasis added)[3]; *see also id*. at 5:25-27 ("It is also possible to use direct injection of gasoline as well as direct injection of ethanol." (emphasis added)).

[3] During a recent discovery dispute, Ford argued that these statements actually amount to a critique of the use of gasoline, which Ford argued show the patentees did not intend their invention to cover the use of gasoline. The opposite is true. These statements expressly disclose that gasoline can be a directly injected fuel. Moreover, it would not matter if they were a criticism. The Federal Circuit has repeatedly held that "mere criticism of a particular embodiment encompassed in the plain meaning of a claim term is not sufficient to rise to the level of [the] clear disavowal" required to limit a claim. *Thorner*, 669 F.3d at 1366 (citing cases).

Indeed, Ford ignores that—when the patentees actually intended to require use of a fuel other than gasoline—they said so explicitly. For example, dependent Claims 9-10 of the '839 Patent expressly require that the engine use a specific fuel. Ex. 2 at 7:33-36 (requiring "ethanol" and "methanol," respectively). The same is true in independent Claim 15, which recites an embodiment "where the engine is fueled with gasoline and ethanol and where the ethanol is directly injected." Ex. 2 at 8:17-18 (emphasis added). Under basic claim differentiation principles, the fact that these other claims expressly require a fuel other than gasoline (i.e., ethanol and methanol) show it would be improper to exclude "gasoline" from the broad meaning of "fuel." *In-Depth Test*, 2018 WL 5669165, at *3 (refusing to read a limitation present in a dependent claim into the independent claim from which it depended).

Claim 15 also refutes Ford's attempt to artificially preclude the use of a single fuel in both fuel systems because it further demonstrates that, when the patentees intended to require that the directly injected fuel be different from the port injected fuel, they (again) said so explicitly. Ex. 2 at 8:17-18. In fact, as reflected below, the only meaningful difference between Claims 1 and 15 of the '839 Patent is that Claim 15 requires the use of at least two fuels—gasoline and ethanol.

Claim 1:	**Claim 15:**
"A spark ignition engine that is fueled both by direct injection and by port injection wherein above a selected torque value the ratio of fuel that is	"A spark ignition engine which is fueled with port injection of fuel and is also fueled with direct injection of fuel and where above a certain value of

directly injected to fuel that is port injected increases; and wherein the engine is operated at a substantially stoichiometric fuel/air ratio."	torque the ratio of fuel that is directly injected to fuel that is port injected increases and where the engine is operated with a substantially stoichiometric fuel/air ratio and where the engine is fueled with gasoline and ethanol and where the ethanol is directly injected such the octane enhancement from evaporative cooling of the ethanol is greater than the octane enhancement from the intrinsic octane of the ethanol."

Ex. 2 at 7:7-11, 8:11-21 (emphasis added). Claim 15 thus further demonstrates that the "directly injected fuel" terms at issue do not exclude gasoline or require the use of two different fuels. *Comark Commc'ns, Inc. v. Harris Corp.*, 156 F.3d 1182, 1187 (Fed. Cir. 1998) ("There is presumed to be a difference in meaning and scope when different words or phrases are used in separate claims.").

In sum, because the patents expressly disclose the use of gasoline as a directly injected fuel and do not require that the directly injected fuel be different from the fuel that is port injected, Ford's construction should be rejected.

F. "highest loads" ['839 (Claim 6)]

Plaintiffs' Construction:	**Ford's Construction:**
Plain and ordinary (no construction needed). Alternatively, if construed, "engine's highest torques at a given engine speed."	"highest torques"

"Highest loads" is another term that does not need construction. As Dr. Shaver explains, a POSITA readily would understand the term "load" to refer to "the **proportion** of maximum torque at a particular engine speed that a particular engine is capable of outputting. For example, if a particular engine is capable of outputting 400 lb-ft (pound-feet) of torque at an engine speed of 1000 revolutions per minute and is outputting 400 lb-ft of torque at such engine speed, it is understood to be operating at 100% load. Similarly, if it was outputting only 300 lb-ft of torque at that engine speed, it would be understood to be operating at 75% load." Ex. 10 (Shaver Decl.) at ¶¶ 13-14. Further, the word "highest" is a common term that needs no explanation.

Nevertheless, if the Court does construe the term, it should reject Ford's construction because it incorrectly conflates "loads" with "torques" and fails to account for the fact that—because it is a proportionate value—"load" depends both on the engine at issue and the particular engine speed at which it is operating.

Indeed, Ford's own IPR petitions confirm that "loads" and "torques" are not synonymous as it now contends. In its '839 IPR Petition, for example, Ford distinguished "load" from "torque"—arguing "a POSITA, however, would have understood that torque is a measure of the work performed by the engine, and engine load is a **proportional** indicator of torque in the range from minimum torque to maximum torque." Ex. 8 at 5-6 (emphasis added).

The patents likewise demonstrate that "load" is not synonymous with torque. When referring to highest torques, the patents use the term "maximum torque." Ex. 1 at 8:27-9:10; Ex. 3 at 7:62-64 (Claim 7). When discussing the related but ultimately different concept of "load," the specification discusses the proportion of "maximum torque" being output—referencing "0.5 maximum torque" and "0.9 maximum torque." Ex. 1 at 9:1-9:3 (emphases added).

The patents also demonstrate that "engine speed" is relevant to determining "load." Specifically, the patents discuss how the "0.5 maximum torque" and "0.9 maximum torque" values can be derived from "FTP and US06 drive cycles" that plot "the amount of operating time spent at various values of torque and engine speed." Ex. 1 at 8:18-25 (emphasis added).

Dr. Shaver also confirmed that "load" varies based on "engine speed"—explaining that, "because maximum torque varies at different engines speeds, a person of ordinary skill in the art would understand that a particular engine's maximum or highest torque will vary depending on engine speed such that load varies depending on the engine speed." Ex. 10 (Shaver Decl.) at ¶ 14.

For all of the above reasons, Ford's construction should be rejected.

G. **“closed loop control that utilizes a sensor that detects knock”** [’519 (Claim 1)]

Plaintiffs’ Construction:	Ford’s Construction:
Plain and ordinary (no construction needed). Alternatively, if construed, “a feedback system that uses a sensor that detects knock.”	“a microprocessor that uses a direct feedback input signal from a knock sensor”

“input from the knock sensor is utilized in a closed loop control system that controls” [’519 (Claim 14)]

Plaintiffs’ Construction:	Ford’s Construction:
Plain and ordinary (no construction needed). Alternatively, if construed, “input from the knock sensor is used by a feedback system that controls.”	“a direct feedback input signal from the knock sensor is used by a microprocessor to control”

“where closed loop control with a knock detector is used” [’519 (Claim 18)]

Plaintiffs’ Construction:	Ford’s Construction:
Plain and ordinary (no construction needed). Alternatively, if construed, “where a feedback system with a knock sensor is used.”	“a direct feedback input signal from the knock detector is used by a microprocessor”

These terms likewise do not need construction. Rather, as Dr. Shaver explains, a POSITA would readily understand the terms “closed loop control” and “knock sensor.” Ex. 10 (Shaver Decl.) at ¶¶ 7-10. Indeed, in its IPR filings, Ford argued that both terms have plain and ordinary meanings. Ex. 8 (’839 IPR Petition) at 51-52 (stating that a “POSITA would understand that knock sensors were known and commonly used” to “monitor[] structure-borne noise” and that, in “(closed loop) control," the "circuit adjusts the engine by means of an actuator" in response to feedback).

If the Court does construe the terms, however, it should reject Ford's constructions, which (1) impose an artificial "microprocessor" limitation, (2) improperly require that the "feedback input signal" be "direct," and (3) redefine each claim's scope by rewriting their text.

First, the Court should reject Ford's attempt to add a "microprocessor" limitation to the claims. Not only does such a limitation violate the bedrock rule against importing limitations from a preferred embodiment into the claims, but it is inconsistent with the patents, which—in addition to disclosing an embodiment that "may use a "microprocessor"—describe embodiments that use a "fuel management microprocessor system," an "engine system," or simply a "fuel management system." Ex. 1 at 4:15-17, 9:26-10:1; Ex. 3 at 7:25-43, 8:14-30.

When the patentees intended a "microprocessor" limitation, they said so directly. For example, Claim 4 of the '839 Patent claims "[t]he spark ignition engine of claim 3 further including a microprocessor that controls the ratio of the directly injected fuel to the port injected fuel based on the signal from the knock detector." Ex. 2 at 7:18-21 (emphasis added). Basic claim differentiation principles thus dictate that a "microprocessor" limitation cannot be read into those claims that do not expressly require a "microprocessor."

Second, nothing in the claims or the specification require that the feedback be direct. Rather, when the specification describes a "feedback signal," it states that, "[a]lternatively, the gasoline engine may include a knock sensor that provides a feedback signal"—not a **direct feedback input signal**—"to a fuel management microprocessor system." Ex. 1 at 3:22-25 (emphasis added). In short, the patents do not require that the feedback be direct, and the Court should reject Ford's attempt to add it. *In-Depth Test*, 2018 WL 5669165, at *2.

Moreover, when Plaintiffs asked Ford to explain what it intended by "direct feedback," Ford stated that it meant that the microprocessor (1) must receive the signal directly from the knock sensor and (2) then use it—without regard for other inputs—to vary the fueling provided by the first fueling system. That limitation is directly at odds with the specification, which explains that the signal from a knock sensor is simply "an input," i.e., one of several, that can be used by the closed loop control "system" to determine which of several actions to take. Ex. 1 at 4:21-24 (emphasis added); *Baldwin*, 512 F.3d at 1342 ("an" means "one or more").

Ford's limitation also conflicts with the '519 Patent's claims, which state that other "sensed information" can be received by "the fuel management system" and that "both the sensed information and information about knock are used to control the fuel that is introduced by the first fueling system." Ex. 3 at 7:53-57 (Claim 5);

id. at 8:24-26 (Claim 13) (stating "the fuel management system uses input that includes input from the sensed parameter and input from knock sensor").

Finally, the Court also should reject Ford's attempt to redefine each claim to require that fueling be adjusted based on the "direct feedback input signal from the knock sensor." As shown below, Ford's construction incorrectly shifts the focus of Claim 14 from requiring use of a knock sensor as part of a "closed loop control system that controls" fueling to requiring that the "direct feedback input signal from the knock sensor" be used to control fueling:

Claim Language:	**Ford's Construction:**
[14] "where input from the knock sensor is utilized in a closed loop control system that controls the fraction of fuel that is introduced into the first fueling system"	"where a direct feedback input signal from the knock sensor is used by a microprocessor to control the fraction of fuel that is introduced into the first fueling system"

Ford's Claim 1 and Claim 18 constructions make the same mistake. As demonstrated below, both shift the focus of the claims from requiring the use of a closed loop control system (that includes a knock sensor) to control fueling to requiring use of a direct feedback input signal from a knock sensor to control fueling—precluding the possibility of the other inputs that, as explained above, the patents expressly contemplate.

Claim Language:	**Ford's Construction:**
[1] "the fuel management system controls the change in the fraction of fuel introduced by the first fueling	"the fuel management system controls the change in the fraction of fuel introduced by the first fueling system

system using closed loop control that utilizes a sensor that detects knock”	using a microprocessor that uses a direct feedback input signal from a knock sensor”
[18] “where closed loop control with a knock detector is used to increase the relative amount of fuel from the first fueling system”	“where a direct feedback input signal from the knock detector is used by a microprocessor to increase the relative amount of fuel from the first fueling system”

For all of the above reasons, to the extent the Court construes these terms, it should reject Ford’s constructions and adopt the alternative constructions Plaintiffs propose, which simply accord “closed loop control” its plain and ordinary meaning of “feedback system.” Ex. 1 at 3:22-25 (“[T]he gasoline engine may include a knock sensor that provides a feedback signal to a fuel management microprocessor system to minimize the amount of the ethanol added to prevent knock in a closed loop fashion.” (emphases added)); Ex. 10 (Shaver Decl.) at ¶ 9.

Dated: October 9, 2019

Respectfully submitted,

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<u>WORD COUNT CERTIFICATION</u>

The undersigned counsel hereby certify that Plaintiffs' Opening Claim Construction Brief contains 5,458 words, which were counted by Brian E. Farnan by using the word count feature in Microsoft Word, in 14-point Times New Roman font. The foregoing word count does not include the cover page or the counsel blocks.

Dated: October 9, 2019

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EXHIBIT 8

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

FORD MOTOR COMPANY

Petitioner

v.

ETHANOL BOOSTING SYSTEMS, LLC, and MASSACHUSETTS INSTITUTE OF TECHNOLOGY,

Patent Owner

Case: IPR2019-01400

U.S. Patent No. 8,069,839

PETITION FOR *INTER PARTES* REVIEW UNDER 35 U.S.C. §312 AND 37 C.F.R. §42.104

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LIST OF EXHIBITS

Exhibit	Short Name	Description
Ex. 1001	’839 Patent	U.S. Patent No. 8,069,839
Ex. 1002	’839 File History	File History of U.S. Patent No. 8,069,839
Ex. 1003	Clark Declaration	Declaration of Dr. Nigel N. Clark under 37 C.F.R. §1.68
Ex. 1004	Clark CV	*Curriculum Vitae* of Dr. Nigel N. Clark
Ex. 1005	Kobayashi	U.S. Patent No. 7,188,607
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Ex. 1007	Rubbert	German Patent Application No. DE19853799
Ex. 1008	Kinjiro	Japanese Patent Application Publication No. JP2002227697
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Ex. 1018	’572 File History	File History of U.S. Patent No. 7,971,572

Exhibit	Short Name	Description
Ex. 1019	’233 File History	File History of U.S. Patent No. 7,762,233
Ex. 1020	’004 File History	File History of U.S. Patent No. 7,740,004
Ex. 1021	’033 File History	File History of U.S. Patent No. 7,314,033
Ex. 1022	Complaint	Complaint for Patent Infringement, *Ethanol Boosting Sys LLC v. Ford Motor Co.*, D.I. 1, C.A. No. 19-cv-196-CFC (D. Del. Jan. 30, 2019)
Ex. 1023	Defendant’s Answer	Defendant’s Answer, Defenses, Counterclaims and Jury Demand, *Ethanol Boosting Sys LLC v. Ford Motor Co.*, D.I. 1, C.A. No. 19-cv-196-CFC (D. Del. March 25, 2019)
Ex. 1024	Plaintiff’s Answer	Answer to Defendant’s Counterclaims, *Ethanol Boosting Sys LLC v. Ford Motor Co.*, D.I. 1, C.A. No. 19-cv-196-CFC (D. Del. April 15, 2019)
Ex. 1025	Heywood	John B. Heywood, *Internal Combustion Engine Fundamentals* (1988)
Ex. 1026	’735 File History	File History of U.S. Patent No. 8,082,735
Ex. 1027	’157 File History	File History of U.S. Patent Application No. 11/758,157
Ex. 1028	Kreikemeier	U.S. Patent No. 6,681,752
Ex. 1029	Takehiko	Japanese Patent Application Publication No. JP63230920
Ex. 1030	’717 File History	File History of U.S. Patent Application No. 13/591,717
Ex. 1031	Bosch	Bosch Automotive Handbook (3rd Ed.)

Exhibit	Short Name	Description
Ex. 1032	Stokes	J. Stokes et al. "A gasoline engine concept for improved fuel economy—the lean-boost system," SAE paper 2001-01-2902, 1-12
Ex. 1033	RESERVED	RESERVED
Ex. 1034	Csere	Csere, C. "A Smarter Way to use Ethanol to Reduce Gasoline Consumption," (2007), https://www.caranddriver.com/features/a15147006/a-smarter-way-to-use-ethanol-to-reduce-gasoline-consumption/
Ex. 1035	RESERVED	RESERVED
Ex. 1036	Infringement Contentions	MIT's/EBS's Preliminary Infringement Chart (Ex. A – U.S. Patent No. 8,069,839), *Ethanol Boosting Sys LLC v. Ford Motor Co.*, D.I. 35, C.A. No. 19-cv-196-CFC (D. Del. July 1, 2019)
Ex. 1037	Mullins Declaration	Declaration of Dr. James L. Mullins under 37 C.F.R. §1.68
Ex. 1038	Mullins CV	*Curriculum Vitae* of Dr. James L. Mullins
Ex. 1039	RESERVED	RESERVED

Ford Motor Company ("Petitioner" or "Ford") hereby petitions for *Inter Partes* Review ("IPR") under 35 U.S.C. §§311–319 and 37 C.F.R. §42 of Claims 1-8 ("the challenged claims") of U.S. Patent No. 8,069,839 ("the '839 Patent"). Petitioner respectfully submits that IPR should be instituted and the challenged claims canceled.

I. GROUNDS FOR STANDING UNDER 37 C.F.R. §42.104(a)

Petitioner certifies that the '839 Patent is available for IPR and that Petitioner is not barred or estopped from requesting an IPR.

II. PAYMENT OF FEES

Petitioner authorizes the Patent Office to charge Deposit Account No. 16-0605 for any additional fees.

III. OVERVIEW OF CHALLENGES AND RELIEF REQUESTED

Pursuant to Rules 42.22(a)(1) and 42.104(b)(1)–(2), Petitioner requests cancellation of the challenged claims in view of the grounds set forth below. Detail on how the claims are construed and where each element can be found in the cited prior art is provided herein. Additional support for each ground is provided in Ex. 1003– Declaration of Nigel Clarke ("Clarke"). ¶9 *et seq*.

Ground 1: Claims 1, 2, and 5-8 are anticipated by Takehiko under pre-AIA 35 U.S.C. §102(b).

Ground 2: Claims 3 and 4 are unpatentable under pre-AIA 35 U.S.C. §103(a) over Takehiko in view of Kobayashi.

Ground 3: Claims 1-4, 6, and 7 are anticipated by Kinjiro under pre-AIA 35 U.S.C. §102(b).

Ground 4: Claim 5 is unpatentable under pre-AIA 35 U.S.C. §103(a) over Kinjiro in view of Kobayashi.

Ground 5: Claims 1-5 and 8 are unpatentable under pre-AIA 35 U.S.C. §103(a) over Rubbert in view of Bosch.

IV. BACKGROUND OF ’839 PATENT AND STATE OF THE ART

A. The ’839 Patent

The ’839 Patent describes an engine that relies specifically on an antiknock agent to eliminate knock, with the antiknock agent being a liquid fuel with a higher octane number than gasoline, such as ethanol, to improve engine efficiency. Ex. 1001, 1:14-17, 1:66-2:15; Ex. 1003, ¶¶35-39.

B. ’839 Patent Prosecution History

The ’839 Patent was granted from the fifth in a family of U.S. patent applications. Ex. 1003, ¶54. The US applications are all continuations of U.S. Application No. 10/991,774 (“the ’774 Application”), filed November 18, 2004.

The prosecution histories of the ’839 Patent and its ultimate parent, U.S. Patent No. 7,314,033 (“the ’033 Patent”), which resulted from the ’774

Application, provide useful information regarding claim construction and a general history of how the challenged claims developed. Ex. 1003, ¶¶54-88.

No Office Actions were issued for the ’839 Patent following Patent Owner’s submission of two Preliminary Amendments with new claim sets after filing. Ex. 1002, 1-5, 61-65, 73-79.

However, in the ’033 Patent prosecution history, Patent Owner repeatedly characterized the alleged invention in Examiner Interviews. For example, in response to the first Office Action, Patent Owner amended Claims 1 and 30 to emphasize that the fuel/ethanol is a liquid and that DI of the liquid fuel/ethanol is “for vaporization in the cylinder to provide charge cooling.” Ex. 1021, 83, 85; Ex. 1003, ¶81. In an Interview, the inventors distinguished the Cantwell reference by arguing that “alkali metal compounds are not a fuel and are not introduced in the liquid state,” water is not a fuel, and the reference only teaches introducing a vaporized material rather than a liquid into the combustion chamber, which would not provide the change-of-state cooling effect. Ex. 1021, 89; Ex. 1003, ¶81. The inventors distinguished the Krauja reference by arguing that the reference did not teach an anti-knock agent because it operated on 100% ethanol. *Id*. To overcome the Payne reference, the inventors argued that the Examiner had not shown that the recitation of “‘any other liquid preparation to suppress auto-ignition’ includes any liquid fuel” rather than water. Ex. 1021, 90; Ex. 1003, ¶81. Finally, to overcome the Coakwell reference, the inventors argued that hydrogen peroxide is introduced to provide free oxygen and "is not itself a fuel." *Id*. In the Final Office Action, the Examiner cited new references, and, in response, Patent Owner identified new limitations, namely "means for port fuel injection of gasoline from the first source" and "means for direct fuel injection of liquid denatured alcohol from the second source," that distinguish over the prior art. Ex. 1021, 129; Ex. 1003, ¶¶82-83. Patent Owner also argued that none of the cited references teach the combination of port fuel injection of gasoline and direct injection of liquid denatured ethanol. Ex. 1021, 129; Ex. 1003, ¶83. The Examiner agreed, and, after some additional prosecution, the '033 Patent was granted. Ex. 1021, 129-91; Ex. 1003, ¶¶83-88.

C. <u>'839 Patent Priority Date</u>

The '839 Patent issued from U.S. Patent Application No. 13/117,448 ("the '448 application"), filed May 27, 2011. As discussed above, the '839 Patent ultimately claims the benefit of the '774 application, filed on November 18, 2004. A claim of priority deserves no presumption of correctness because "the PTO does not examine [priority claims] as a matter of course." *Dynamic Drinkware, LLC v. Nat'l Graphics, Inc.*, 800 F.3d 1375, 1380 (Fed. Cir. 2015). The challenged claims are not entitled to the priority date of the priority applications because their disclosures do not demonstrate that Patent Owner was in possession of the alleged invention in these claims.

D. Claim Construction (37 C.F.R. §42.104(b)(3))

Claim terms in a patent are interpreted according to the same claim construction standard used to construe the claim in a civil action under 35 U.S.C. §282(b), including construing the claim in accordance with the ordinary and customary meaning as understood by a person of ordinary skill in the art ("POSITA") under *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005) and its progeny. Petitioner reserves all rights to take a different position with respect to claim construction in any other proceeding.

1. "Selected Torque Value" / "Some Value of Torque"

The terms "selected torque value" and "some value of torque" ("selected torque value") are used throughout the challenged claims to define one or more values at which the engine changes operation from reliance on PI alone to reliance on PI and DI or the engine changes operation from reliance on PI and DI to reliance on DI alone. *See, e.g.*, Ex. 1001, Claims 1, 7, and 8; Ex. 1003, ¶92. The "selected torque value" terms, however, are undefined.[1] Ex. 1003, ¶93.

"Selected torque value" never appears in the '839 Patent specification. For the purposes of this proceeding only, a POSITA, however, would have understood

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[1] Petitioner reserves the right to assert 35 U.S.C. §112 challenges in the co-pending litigation.

that torque is a measure of the work performed by the engine, and engine load is a proportional indicator of torque in the range from minimum torque to maximum torque. Ex. 1003, ¶94. Indeed, the higher the torque, the higher the load, such that the terms "selected torque value" and "selected load value" would have the same operational meaning. *Id.* Indeed, Patent Owner admitted torque and load are the same. Ex. 1036, 2. Where a first specified value of torque and a second specified value of torque fall on a torque-speed map, a first percentage of load and a second percentage of load would similarly fall on a load map. Ex. 1003, ¶94. A POSITA would understand that a "selected torque value" is a value of torque representative of engine load. *Id.* For example, a POSITA would equate moving from one selected torque value to a different torque value to moving from one load value on a load map to a different load value on a load map. *Id.* Patent Owner confirms this interpretation. *See, e.g.*, Ex. 1036, 2, 4.

Accordingly, Petitioner adopts Patent Owner's construction that "selected torque value" should be construed to equate to "selected load value" and mean "a specified value of torque on a torque-speed map" consistent with the ordinary and customary meaning of the term. Ex. 1003, ¶¶94-95.

2. "Port Injection" / "Direct Injection"

Petitioner also advances a construction of "port injection," "direct injection," and variants thereof. "Port injection" (PI) should be construed to mean "injection of fuel through a manifold," and "direct injection" (DI) should be construed to mean "injection of fuel into the cylinder," consistent with their respective ordinary and customary meanings. Ex. 1003, ¶96. In construing these terms, Petitioner adopts Patent Owner's implicit construction and does not limit the type of PI or DI fuel used. *Id*., ¶¶96-101.

The challenged claims themselves do not recite the type of actual fuel(s) injected. Ex. 1003, ¶96. The specification, however, discloses and limits the '839 Patent to two distinct fuel sources, a gasoline tank and a tank containing an antiknock agent (e.g., ethanol).[2] Ex. 1001, FIG. 1; Ex. 1003, ¶97. The '839 Patent appears to use the term "antiknock agent" to describe a different fuel than the PI fuel and, further, uses "antiknock agent" to describe fuels such as ethanol, methanol, etc. Ex. 1001, 1:66-2:6; Ex. 1003, ¶97. The '839 Patent explicitly states that each "antiknock agent" can be characterized as either being high octane fuel or a fuel additive. Ex. 1001, 6:60-67; Ex. 1003, ¶97. Regardless, the '839 Patent

[2] The '839 Patent also discloses an alternative configuration in which a single tank is used. In that embodiment, however, two separate streams are produced by separation from that tank. Ex. 1001, 5:39-41.

identifies DI of ethanol as the object of the present invention.[3] Ex. 1001, 1:54-56; Ex. 1003, ¶98. Patent Owner confirmed this interpretation of the identity of the fuel(s) in the ’033 Patent prosecution history. *See supra* §IV(B); Ex. 1021, 88-90, 129; Ex. 1003, ¶99.

Despite the disclosures in the specification and the ’033 Patent prosecution history (Ex. 1021, 88-90, 129), in the litigation, Patent Owner is asserting its claims against certain Ford EcoBoost engines, which are known to use a single fuel, *e.g.*, gasoline, where the same single fuel is used by both the PI and DI system. Ex. 1022, ¶64; Ex. 1003, ¶101. Accordingly, Petitioner adopts Patent Owner’s broad construction for the purposes of this proceeding, and the challenged claims should be construed to be broad enough to include a system using DI and PI of the same fuel from the same fuel source. Ex. 1003, ¶101. Petitioner’s construction of “port injection” as meaning “injection of fuel through a manifold,” and “direct injection” as meaning “injection of fuel into the cylinder” without further limiting the fuel identity is consistent with Patent Owner’s implicit construction.

V. PRIOR ART REFERENCES

[3] Petitioner reserves the right to assert that the claims are limited to the direct injection of an antiknock agent alone, such as ethanol.

A. <u>U.S. Patent No. 7,188,607 ("Kobayashi")</u>

Kobayashi was filed on June 27, 2003, in the United States and issued on March 13, 2007. Therefore, Kobayashi is prior art under at least pre-AIA 35 U.S.C. §102(e)(1) if the claims are deemed entitled to a priority date of November 18, 2004. Kobayashi is cited on the face of the '839 Patent but was not relied upon by the Examiner during the '839 Patent's prosecution.[4]

B. <u>JPS63230920 ("Takehiko")</u>

Takehiko is a Japanese patent application published in Japan on September 27, 1988. Takehiko is therefore prior art under pre-AIA 35 U.S.C. §102(a) and §102(b). Takehiko is accompanied by a certified translation and the original Japanese language document. Ex. 1029; 37 C.F.R. §42.63(b); 35 U.S.C. §312(a)(5); *Ninebot Tech. Co. v. Inventist, Inc.*, No. IPR2018-00134, Paper No. 11 at 10-11 (P.T.A.B. April 23, 2018).

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[4] Kobayashi was cited during prosecution of related abandoned U.S. Application No. 13/591,717 ("the '717 Application"), where the Examiner rejected Claims 43-45 under 35 U.S.C. §102(e) as being anticipated by Kobayashi. Ex. 1030, 54. Rather than addressing the rejection, Patent Owner merely canceled Claims 43-45. Ex. 1030, 97-100.

C. JP2002227697 (“Kinjiro”)

Kinjiro is a Japanese patent application published in Japan on August 14, 2002. Kinjiro is therefore prior art under pre-AIA 35 U.S.C. §102(a) and §102(b). Kinjiro is accompanied by a certified translation and the original Japanese language document. Ex. 1008; 37 C.F.R. §42.63(b); 35 U.S.C. §312(a)(5); *Ninebot Tech. Co.*, No. IPR2018-00134, Paper No. 11 at 10-11.

D. DE19853799 (“Rubbert”)

Rubbert is a German patent application published in Germany on May 25, 2000. Rubbert is therefore prior art under pre-AIA 35 U.S.C. §102(a) and §102(b). Rubbert is accompanied by a certified translation and the original German language document. Ex. 1007; 37 C.F.R. §42.63(b); 35 U.S.C. §312(a)(5); *Ninebot Tech. Co.*, No. IPR2018-00134, Paper No. 11 at 10-11.

E. Bosch Automotive Handbook (“Bosch”)

Bosch was published in 1993 and was publicly accessible prior to November 18, 2004. *See* Ex. 1037. Indeed, Dr. Mullins located Bosch at the Massachusetts Institute of Technology (MIT) Libraries and Purdue University Libraries and identified that MIT Libraries had added a receipt date of 1993, and Purdue University Libraries had added a receipt date of 1997. Ex. 1037, ¶¶44-50. Dr. Mullins confirmed the accessibility of Bosch at at least MIT and Purdue well before the priority date of the patent at issue. Ex. 1037, ¶¶51-60. Bosch is therefore prior art under pre-AIA 35 U.S.C. §102(a) and §102(b). Bosch is a well-known text on which a POSITA would have relied. Ex. 1003, ¶¶11, 192.

VI. LEVEL OF ORDINARY SKILL IN THE ART

A POSITA at the time of the invention would be expected to have at least a bachelor's degree in engineering and at least five years of experience in the field of internal combustion engine design and controls. Ex. 1003, ¶10. Individuals with different education and additional experience could still be of ordinary skill in the art if that additional experience compensates for a deficit in their education and experience stated above. *Id*. Additional education might substitute for some of the experience, and substantial experience might substitute for some of the educational background. *Id*.

VII. HOW THE CHALLENGED CLAIMS ARE UNPATENTABLE

At the time of the earliest possible priority date, the automobile industry was facing immense pressure to improve fuel economy and to reduce emissions. Ex. 1032, 3; Ex. 1003, ¶31. By early 2000, it was clear to engineers that regulations would soon require manufacturers to develop more environmentally friendly vehicles with more efficient engines. Ex. 1032, 3. Market forces had already led to the development of high specific output, low swept volume "downsized" engines. Ex. 1032, 3.

The ’839 Patent outlines that high compression ratio operation and engine downsizing can improve energy efficiency of spark ignition engines. Ex. 1001, 1:14-20; Ex. 1003, ¶36. The ’839 Patent discloses that engine downsizing is made possible by the use of substantial pressure boosting to obtain the same performance in a significantly smaller engine. Ex. 1001, 1:20-24; Ex. 1003, ¶36. However, the drawback of increased engine efficiency is the onset of engine knock, which “is the undesired detonation of fuel and can severely damage an engine.” Ex. 1001, 1:27-30; Ex. 1003, ¶37.

Understanding that knock was the sole problem the ’839 Patent sought to solve, a POSITA would have understood that there were a finite number of techniques to prevent knock in spark ignition engines—retarding the ignition timing and octane enhancement. Ex. 1003, ¶33.

To address knock, the ’839 Patent relies on an antiknock agent (e.g., ethanol), which the ’839 Patent states provides benefits that could not be achieved with gasoline or a gasoline/ethanol mixture. Ex. 1001, 3:54-57, 4:19-23. Patent Owner likewise advocated for such a system utilizing DI of an antiknock agent in the press. Ex. 1034. However, in an effort to assert its patents and by pursuing an aggressive continuation strategy, Patent Owner appears to have abandoned its ethanol-based innovation, opting instead for generic claims that Patent Owner purports cover a system that relies on PI and DI of the same fuel. Ex. 1022, ¶¶64-70.

As a result of claims that pivoted away from the specification, the ’839 Patent broadly claims the well-known concept of DI as a method for reducing knock. That is, the ’839 Patent only claims what Stokes (admitted prior art in the ’839 Patent) and others had already realized—DI eliminates knock in boosted “downsized” engines—nothing more. Ex. 1032. Indeed, engines that relied on both PI and DI had already been developed well in advance of the ’839 Patent. As evidenced by the prior art discussed below and the knowledge of a POSITA, the ’839 Patent claims recite nothing more than use of the known technique of DI for knock-free operation in an engine that enabled both PI and DI. Ex. 1003, ¶33. The claims of the ’839 Patent therefore must be canceled.

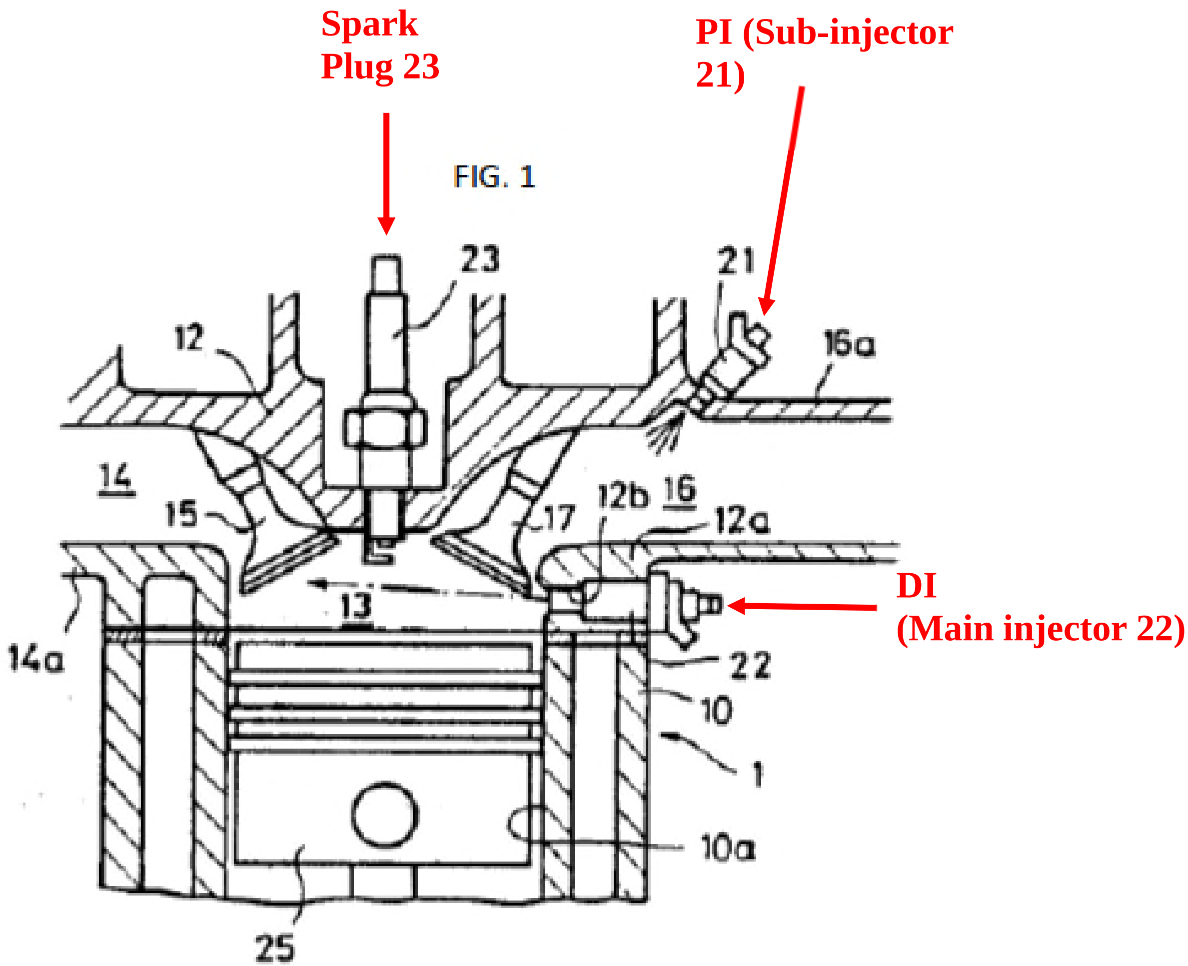
A. <u>Ground 1: Claims 1, 2, and 5-8 are Anticipated by Takehiko Under 35 U.S.C. §102(b)</u>

1. *Claim 1: [1.Pre] A spark ignition engine that is fueled both by direct injection and by port injection*

It is well-understood that the preamble of a claim is generally not limiting, particularly “where a patentee defines a structurally complete invention in the claim body and uses the preamble only to state a purpose or intended use for the invention.” *Catalina Mktg. Int’l, Inc. v. Coolsavings.com, Inc.*, 289 F.3d 801, 808 (Fed. Cir. 2002); *see also Arctic Cat Inc. v. GEP Power Prods., Inc.*, Nos. 18-

1520, 1521, 919 F.3d 1320, 1329 (Fed. Cir. 2019). Moreover, this and other claims do not include a transitional phrase to indicate where the preamble of the claim ends and the body of the claim begins. The Federal Circuit has been clear that "poor claim drafting will not be an excuse for it to infuse confusion into its claim scope." *Acceleration Bay, LLC v. Activision Blizzard, Inc.*, 908 F.3d 765, 770. Here, "that is fueled both by direct injection and port injection" clearly modifies "a spark ignition engine. Accordingly, "that is fueled both by direct injection and port injection" is effectively part of the preamble and not limiting.

To the extent the preamble of Claim 1 is limiting, Takehiko discloses a spark ignition engine that includes two fuel injection valves, one for PI and one for DI for fueling an engine (Fig. 1 below). Ex. 1029, 3; Ex. 1003, ¶¶106-08.



2. *Claim 1: [1.A] wherein above a selected torque value the ratio of fuel that is directly injected to fuel that is port injected increases;*

Takehiko discloses that, in operation, its engine prevents knock from occurring. Ex. 1029, 2; Ex. 1003, ¶109. Specifically, Takehiko discloses that at low loads, PI alone may be used. Ex. 1029, 4; Ex. 1003, ¶109. At higher loads, DI may be used, either alone or in combination with PI depending on the injection volume of main injector 22. *Id*. As such, Takehiko implicitly discloses wherein above a selected torque value the ratio of fuel that is directly injected to fuel that is port injected increases. Ex. 1003, ¶110.

According to the Federal Circuit, inherent anticipation exists when "the missing descriptive matter is necessarily present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill." *Cont'l Can Co. USA, Inc., v. Monsanto Co.*, 948 F.2d 1264, 1268 (Fed. Cir. 1991). A POSITA would understand that Takehiko implicitly teaches the use of open loop control to manage its engine operation, as Takehiko necessarily has a load or torque value whereby its engine begins to rely on DI to prevent knock. Ex. 1003, ¶110. Indeed, Takehiko is silent on the use of knock detectors but instead discloses that knock is ***prevented*** by using PI alone at low loads and DI, either alone or in combination with PI, at higher loads. *See, e.g.*, Ex. 1029, 4 (stating that "generation of knocking in the area around exhaust valve 15 is prevented" and "there is no danger of knocking"); Ex. 1003, ¶110. In doing so, the engine of Takehiko is necessarily programmed to switch from PI only to DI at a predetermined (*i.e.*, selected) threshold computed from variables including load value. Ex. 1003, ¶110.

As a result of its programming and above the predetermined threshold, which is dependent upon load value, the ratio of DI to PI fuel increases from zero DI fuel to a positive value of DI fuel depending on whether PI is used in conjunction with DI. *Id*.[5] That is, the amount of fuel that is directly injected increases from nothing to a positive value based on the torque value.

3. Claim 1: [1.B] and wherein the engine is operated at a substantially stoichiometric fuel/air ratio.

Takehiko discloses that its engine is operated at a substantially stoichiometric fuel/air ratio. Ex. 1029, 4 (disclosing operating the engine "near the ideal air-fuel ratio"). Takehiko teaches the importance of the positioning of main injector 22 within the cylinder. Ex. 1003, ¶111. Specifically, as shown in FIG. 1 below, main injector 22 is positioned opposite exhaust valve 15 in the cylinder. *See also* Ex. 1029, Claim 1; Ex. 1003, ¶111. Fuel injection from main injector 22 is directed toward exhaust valve 15 such that the fuel directly impacts the exhaust valve. Ex. 1029, 4; Ex. 1003, ¶111. As a result, "the area around exhaust valve 15 is cooled and generation of knocking in the area around exhaust valve 15 is prevented." *Id*.

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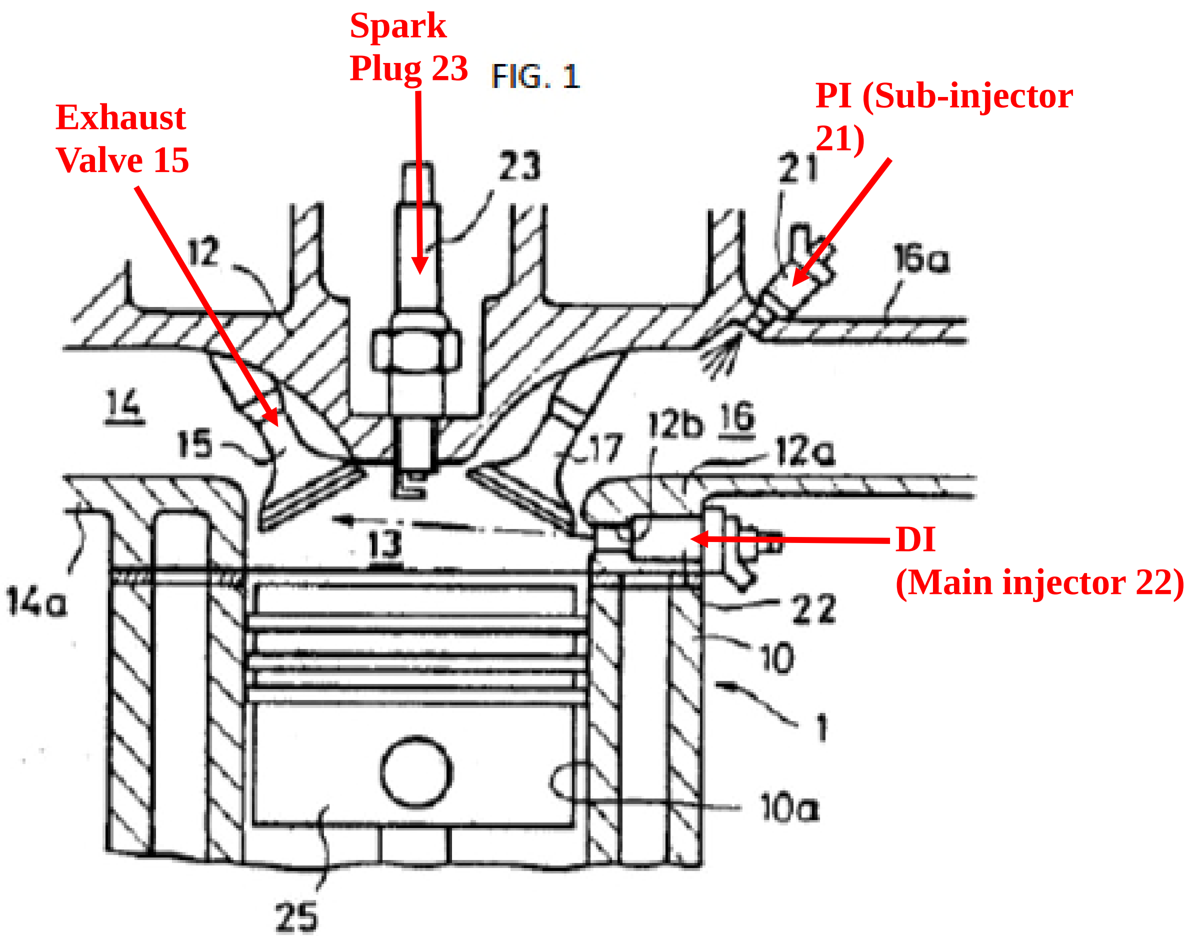
[5] Similarly, Patent Owner asserts that a system where allegedly "fuel delivery occurs via 'PI alone at idle and at low rpm,' but '[a]s rpm and load increase, fuel delivery becomes a programmed blend of PI and DI'" infringes this claim element. Ex. 1036, 1.



Takehiko discloses that because of this configuration of main injector 22 and exhaust valve 15, enrichment is not needed to avoid knock in the engine. Ex. 1029, 4; Ex. 1003, ¶112. Takehiko further attributes these desired results to DI generally, stating that "all of the latent heat of vaporization which the fuel has can be effectively utilized within combustion chamber 13, improvement anti-knock characteristics as well as improvement in packing efficiency through cooling of the intake air can be expected, and output power is increased." *Id*. Due to the use and positioning of DI, Takehiko discloses that its engine is able to provide knock-free operation near the "ideal air-fuel ratio." *Id*.

Indeed, Takehiko's use of the term "ideal air-fuel ratio" reinforces Takehiko's assertion that the described engine controls knock without enrichment. Ex. 1003, ¶112. The term "ideal air-fuel ratio" is synonymous with the term "stoichiometric air-fuel ratio." *Id.*, ¶113.

4. *Claim 2: The spark ignition engine of claim 1 where the ratio of directly injected fuel to port injected fuel increases with increasing torque.*

Takehiko discloses increasing the ratio of DI fuel to PI fuel with increasing torque. *See supra* §VII(A)(2); Ex. 1029, 2, 4; Ex. 1003, ¶114. Indeed, the engine of Takehiko is programmed to switch from PI only to DI at a predetermined (*i.e.*, selected) threshold computed from variables including load value. Ex. 1003, ¶114. Above this predetermined threshold, which is dependent upon load value, the ratio of DI to PI fuel would increase from zero to a positive value depending on whether PI is used in conjunction with DI. *Id.*

5. *Claim 5: The spark ignition engine of claim 2 where open loop control is used to determine the ratio of the directly injected fuel to the port injected fuel.*

A POSITA would understand that Takehiko implicitly discloses using open loop control to determine the ratio of DI to PI fuel. Ex. 1003, ¶¶115-17. According to the Federal Circuit, inherent anticipation exists when "the missing descriptive matter is necessarily present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill." *Cont'l Can Co. USA, Inc.*, 948 F.2d at 1268. A POSITA would understand that Takehiko implicitly teaches the use of open loop control to manage its engine operation, as Takehiko necessarily has a load or torque value whereby its engine begins to rely on DI to prevent knock. Ex. 1003, ¶117.

Indeed, Takehiko is silent on the use of knock detectors but instead discloses that knock is ***prevented*** by using PI alone at low loads and DI, either alone or in combination with PI, at higher loads. *See, e.g.*, Ex. 1029, 4 (stating that "generation of knocking in the area around exhaust valve 15 is prevented" and "there is no danger of knocking"); Ex. 1003, ¶117. In doing so, the engine of Takehiko is programmed to switch from PI only to DI at a predetermined (*i.e.*, selected) threshold computed from variables including load value. Ex. 1003, ¶117. Above this predetermined threshold, which is dependent upon load value, the ratio of DI to PI fuel would increase from zero to a positive value depending on whether PI is used in conjunction with DI. *Id.* Thus, a POSITA would understand that Takehiko necessarily uses open loop control. *Id.*

6. Claim 6: The spark ignition engine of claim 1 where the engine operates at a substantially stoichiometric fuel/air ratio at the highest loads.

"Highest loads" refers to the region of operation with the highest requirement for knock management. Ex. 1003, ¶118. As discussed with respect to Limitation 1.B, Takehiko discloses that its engine operates at a substantially stoichiometric fuel/air ratio. *See supra* §VII(A)(3); Ex. 1029, 4; Ex. 1003, ¶¶119-22. Takehiko also discloses that its engine operates at a substantially stoichiometric fuel/air ratio at the highest loads because at the ideal, or stoichiometric, fuel/air ratio, "there is no danger of knocking, full-load, high-speed (MTB) driving is possible, and improvement in fuel economy during high-speed driving can be expected." Ex. 1029, 4; Ex. 1003, ¶120.

7. *Claim 7: The spark ignition engine of claim 1 where the engine operates at some value of torque with port fuel injection alone.*

Takehiko discloses that PI alone can be used at low loads. *See supra* §VII(A)(2); Ex. 1029, 2, 4; Ex. 1003, ¶123. Specifically, Takehiko discloses that "at times of low-load driving, such as when idling, it is acceptable to supply injected fuel into intake port 16 from sub-injector 21 without supplying injection from main injector 22." Ex. 1029, 4.

8. *Claim 8: The spark ignition engine of claim 1 where the engine operates at some value of torque with direct injection alone.*

Takehiko discloses that DI can be used alone or in combination with PI at higher loads: "[t]he amount of fuel supplied to engine 1 from main injector 22 is limited by the amount that can be supplied by injection by main injector 22 during the fuel injection period….if it is designed so that main injector 22 is one with a large injection volume, ***sub-injector 21 may be omitted***." Ex. 1029, 4 (emphasis added); Ex. 1003, ¶124.

B. <u>Ground 2: Claims 3 and 4 are unpatentable under pre-AIA 35 U.S.C. §103(a) over Takehiko in view of Kobayashi</u>

1. Overview of Ground 2

Independent claim 1 recites a spark ignition engine that uses DI and PI. The claim recites that the engine is operated at a substantially stoichiometric fuel/air ratio. The claim further recites that the ratio of DI to PI fuel increases above a selected torque value. Claims 3 and 4 depend from independent claim 1 and both recite that the ration of DI to PI fuel is based on the signal from a knock detector. Claim 4 further requires a microprocessor to control the ratio of DI to PI fuel based on the signal from the knock detector.

i. Overview of Takehiko and Kobayashi

Similarly, Takehiko is directed to a spark ignition engine that relies PI and DI for fueling an engine. Ex. 1029, 3; Ex. 1003, ¶130. In operation, the engine of Takehiko prevents knock from occurring. Ex. 1029, 2; Ex. 1003, ¶130. Takehiko discloses that at low loads, PI alone may be used. Ex. 1029, 4; Ex. 1003, ¶130. At higher loads, DI may be used, either alone or in combination with PI depending on the injection volume (e.g., rate of volume delivery) of main injector 22. *Id*. Thus, Takehiko discloses transitioning from PI alone at low load conditions where knocking is unlikely to occur to directly injecting a proportion of the fuel at higher loads, where knocking is likely to occur. *Id*. Takehiko is silent regarding a need for a knock detector. However, a POSITA would have understood that conventional spark ignition engines would have included a knock detector, which is illustrated by Kobayashi. Ex. 1003, ¶131.

Kobayashi discloses the reliance on an ECU to control the operations of the engine. Ex. 1005, 10:16-17; Ex. 1003, ¶131. One particular function of the ECU is to detect the occurrence of knocking based on output from a knock sensor. Ex. 1005, 10:34-48; Ex. 1003, ¶131. Kobayashi discloses DI of hydrogen gas or other liquid fuel (e.g., ethanol) to reduce knock in response to the knock detector (e.g., closed loop control). Ex. 1005, 5:65-6:2, 11:57-64; Ex. 1003, ¶131. Kobayashi also discloses open loop control in at least FIG. 3. Ex. 1005, FIG. 3, 11:29-31, 13:14-20; Ex. 1003, ¶131.

ii. Motivation to Combine

Takehiko is silent regarding a need for a knock detector. However, a POSITA would have understood that conventional spark ignition engines would have included a knock detector. Ex. 1003, ¶131. As such, the POSITA would have looked to other systems that provide both direct injection and port fuel injection to provide the necessary implementation details for a knock detector. A POSITA would have combined the teachings of open loop control of Takehiko with the knock detector of Kobayashi to suppress knock. *Id.*

Based on Kobayashi, a POSITA would have understood that there were benefits in using both open loop control and closed loop control in an engine control system. Ex. 1003, ¶132. Open loop control is used to establish an engine operating point at which DI supplements PI to avoid engine knock. *See, e.g.*, Ex. 1005, 11:57-64; Ex. 1003, ¶132. Closed loop control using a knock detector further protects an engine from knock by taking countermeasures in the event knock is encountered. Ex. 1005, 5:65-6:2; 11:57-64; Ex. 1003, ¶132. Indeed, a knock detector provides real time feedback from an engine and addresses a knock condition experienced by an engine, which can still occur despite using open loop control to avoid knock. Ex. 1003, ¶132. Using open loop control, as in Takehiko, reduces the likelihood that knock will be experienced by supplementing PI with DI under conditions prone to knocking (e.g., high load conditions). *See, e.g.*, Ex. 1029, 4; Ex. 1003, ¶132. Using closed loop control, as described by Kobayashi, provides knock reduction when knock occurs. Ex. 1003, ¶132.

Further, using closed loop control for knock-free assurance facilitates the use of less conservative open loop lookup tables. Ex. 1003, ¶132. The open loop control of Takehiko would not be expected to protect against knock given worst-case scenario conditions (e.g., very low quality/low octane fuel and high engine temperatures) unless the open loop control strategy was so cautious to avoid knock that it would undermine the efficiency of the engine. *Id.* The POSITA would have also understood that relying on a knock sensor alone could result in reduced efficiency and output, as the system would be purely reactive and not proactive. *Id.*

As such, it would be apparent to a POSITA to utilize both open loop control, as in Takehiko, and closed loop control, as in Kobayashi. Ex. 1003, ¶132. Indeed, the POSITA would have understood that the use of a fuel map with a knock detector would provide the ability to achieve high engine efficiency with lower emissions, while protecting against knock or other damaging conditions. *Id.* The use of open loop maps in conjunction with feedback control from sensors was commonplace at the time the ’839 Patent was filed. *Id.* For example, open loop maps combined with feedback control from oxygen sensors were used to manage air/fuel ratio in PI vehicles at the time the ’839 Patent was filed. *See, e.g.*, Ex. 1028, 1:31; Ex. 1003, ¶132. As a result, the POSITA would have relied on the knock detector as disclosed in the Kobayashi reference. Ex. 1003, ¶132.

The POSITA would have had a reasonable expectation of success given that Takehiko and Kobayashi rely on the use of PI and DI at high loads. Ex. 1003, ¶133. As such, the POSITA would have understood that inclusion of the knock detector of Kobayashi with the teachings of Takehiko would have been a straightforward modification that would have a reasonable expectation of success. *Id.* Indeed, such a modification was simply the addition of a well-known knock sensor to the engine of Takehiko. *Id.*

2. *Claim 3: The spark ignition engine of claim 2 where the ratio of directly injected fuel to port injected fuel is determined by a signal from a knock detector.*

A POSITA would understand that Takehiko implicitly discloses using open loop control to determine the ratio of DI to PI fuel. *See supra* §VII(A)(2); Ex. 1029, 2, 4; Ex. 1003, ¶134. Takehiko is silent as to the use of a knock detector. Ex. 1003, ¶135. However, the POSITA would have combined the teachings of open loop control of Takehiko with the knock detector of Kobayashi to suppress knock. *Id.*

Kobayashi supplements Takehiko and discloses the reliance on an ECU to control the operations of the engine. Ex. 1005, 10:16-17; Ex. 1003, ¶136. One particular function of the ECU is to detect the occurrence of knocking based on output from a knock sensor. Ex. 1005, 10:34-48; Ex. 1003, ¶136. Kobayashi discloses DI of hydrogen gas or other liquid fuel to reduce knock in response to the knock detector. Ex. 1005, 5:65-6:2; 11:57-64; Ex. 1003, ¶136.

Kobayashi also discloses open loop control in at least FIG. 3. *See also* Ex. 1005, 11:29-31, 13:14-20; Ex. 1003, ¶136. Specifically, Kobayashi discloses "FIG. 3 is a flowchart showing an engine operation control routine executed by the ECU 30." Ex. 1005, 11:29-31. Further, S106 of Figure 3 "determine fuel injection quantity and intake air quality" would rely on a lookup table (e.g., a corresponding map). Ex. 1005, 13:14-20. Moreover, in S112, the discriminator for determining high load conditions would likewise rely on a lookup table. Ex. 1003, ¶136.

Based on Kobayashi, a POSITA would have understood the benefits of using both open loop control and closed loop control. Ex. 1003, ¶137. Open loop control using a fuel map to establish an engine operating point at which DI is used to supplement PI is used to avoid engine knock. *See, e.g.*, Ex. 1005, 11:57-64; Ex. 1003, ¶137. Closed loop control using a knock detector further protects an engine from knock by taking countermeasures in the event knock is encountered. Ex. 1005, 5:65-6:2; 11:57-64; Ex. 1003, ¶137. Specifically, a knock detector provides real time feedback from an engine and addresses a knock condition experienced by an engine, which can still occur despite using open loop control to avoid knock. Ex. 1003, ¶137.

Using open loop control, as in Takehiko, reduces the likelihood that knock will be experienced by supplementing PI with DI under conditions that are prone to knocking, such as high load conditions. *See, e.g.*, Ex. 1029, 4; Ex. 1003, ¶137. Using closed loop control provides knock reduction when knock is experienced, which may be caused by factors such as fuel octane, engine, coolant, or air temperatures, or the like. Ex. 1003, ¶137. The open loop control of Takehiko would not be expected to protect against knock given worst-case scenario conditions (e.g., very low quality/low octane fuel and high engine temperatures) unless the open loop control strategy was so cautious to avoid knock that it would undermine the efficiency of the engine. *Id*.

The POSITA would have also understood that relying on a knock sensor alone could result in reduced efficiency and output, as the system would be purely reactive and not proactive. Ex. 1003, ¶137. As such, it would be obvious to a POSITA to utilize both open loop control, as in Takehiko, and closed loop control, as in Kobayashi. *Id.* Indeed, the POSITA would have understood that the use of a fuel map with a knock detector would provide the ability to achieve high engine efficiency with lower emissions, while protecting against knock or other damaging conditions. *Id.* As a result, the POSITA would have relied on the knock detector of Kobayashi. *Id.*

3. Claim 4: The spark ignition engine of claim 3 further including a microprocessor that controls the ratio of the directly injected fuel to the port injected fuel based on the signal from the knock detector.

Takehiko relies on open loop control rather than closed loop control (e.g., a knock detector); however, the POSITA would have combined the teachings of open loop control of Takehiko with the knock detector of Kobayashi so as to suppress knock. *See supra* §VII(B)(2); Ex. 1029, 4; Ex. 1005, 5:65-6:2, 10:16-17, 10:34-48, 11:29-31, 11:57-64, 13:14-20; Ex. 1003, ¶¶139-42.

Kobayashi discloses the reliance on an ECU to control the operations of the engine. Ex. 1005, 10:16-17; Ex. 1003, ¶140. One particular function of the ECU is to detect the occurrence of knocking based on output from a knock sensor. Ex. 1005, 10:34-48; Ex. 1003, ¶140. A POSITA would understand that an ECU is an electronic controller and equivalent to a microprocessor. Ex. 1003, ¶140.

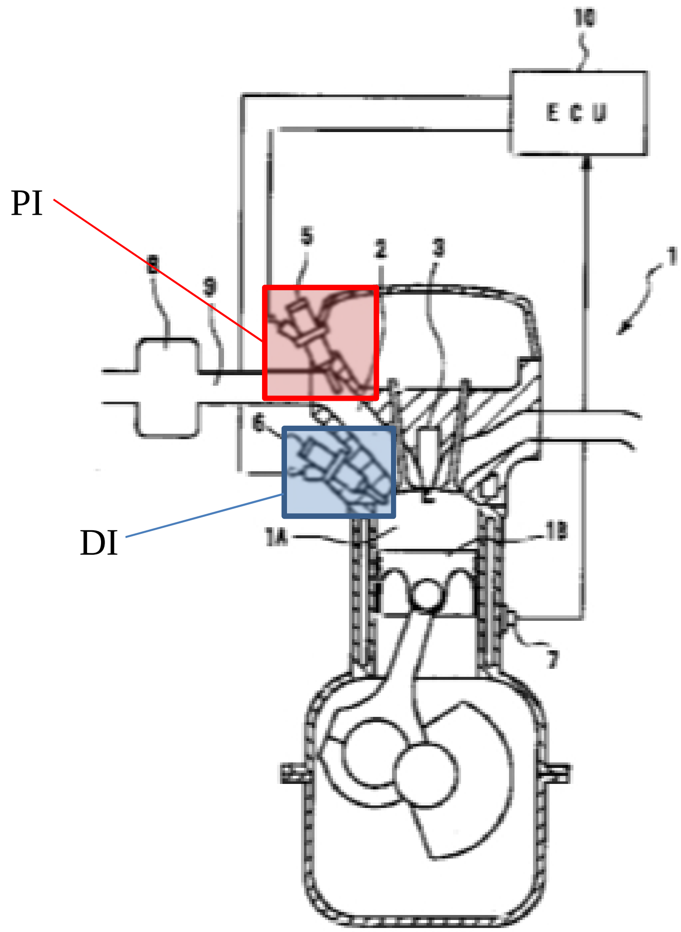
C. <u>Ground 3: Claims 1-4, 6, and 7 are Anticipated by Kinjiro Under 35 U.S.C. §102(b)</u>

1. *Claim 1: [1.Pre] A spark ignition engine that is fueled both by direct injection and by port injection*

The preamble of a claim is generally not limiting for the reasons set forth with respect to Claim 1 in Ground 1. *See supra* §VII(A)(1).

To the extent the preamble of Claim 1 is limiting, Kinjiro discloses a spark ignition engine (shown below in FIG. 1). Ex. 1008, ¶¶[0011]-[0012]; Ex. 1003, ¶¶149-51. The engine is fueled by a PI valve provided in each intake passage and a DI valve that has an "injection hole preferably disposed in the combustion chamber so as to inject fuel directly into the combustion chamber." Ex. 1008, ¶¶[0010]-[0011]; Ex. 1003, ¶150.

[FIG. 1]



2. ***Claim 1: [1.A] wherein above a selected torque value the ratio of fuel that is directly injected to fuel that is port injected increases;***

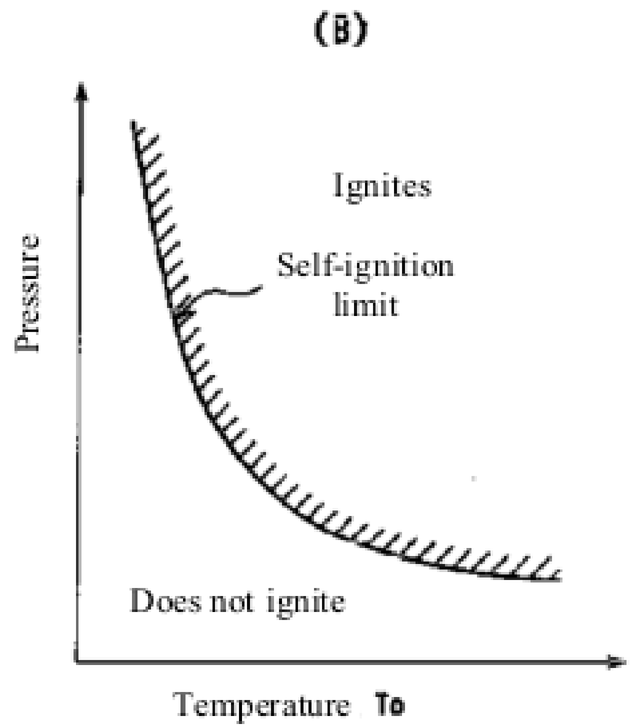
Kinjiro discloses a knock sensor 7. Ex. 1008, ¶[0012]; Ex. 1003, ¶152. Information detected by the knock sensor 7 is input to ECU 10, which sets an operation control signal for each of the injectors 5 and 6. Ex. 1008, ¶[0014]; Ex. 1003, ¶152. Kinjiro discloses two modes of operation. First, Kinjiro discloses a normal operating state. *Id*. In the first or normal operating state, Kinjiro discloses that when knock has not been detected, the engine is fueled by PI alone. *Id.* Second, Kinjiro discloses a second or split injection mode. *Id.* Engine 1 enters the second or split injection mode upon the detection of knock in the first or normal operating state. Ex. 1008, ¶[0014], Figure 5; Ex. 1003, ¶152. This onset of knock would be associated with an increase in torque, for instance, as a result of increasing temperature and/or cylinder pressure.

In the split injection mode, Kinjiro discloses that fuel injection is performed by both PI and DI. Ex. 1008, ¶[0014]; Ex. 1003, ¶153. Therefore, in the first, or normal, operating state, no DI fuel is used. Ex. 1003, ¶153. In the mode where knock would otherwise occur, both PI and DI are employed. *Id.* Therefore, the ratio of DI to PI increases from reliance on no DI fuel to some amount of DI fuel as operation moves from the normal operating state to the split injection mode. *Id.*

Furthermore, Kinjiro discloses that as in cylinder temperature increases during the split injection mode an increase in the ratio of DI fuel to the amount of PI fuel would necessarily occur. Ex. 1003, ¶154. Such an increase in cylinder temperature would result, e.g., from an increase in torque. *Id.*

For instance, Kinjiro discloses that increased temperature or pressure in the combustion chamber increases the engine's tendency to knock. Ex. 1008, ¶[0002]; Ex. 1003, ¶155. FIG. 6B illustrates that pressure and temperature define a zone in which knocking will occur and a zone in which knocking will not occur. Ex. 1003,

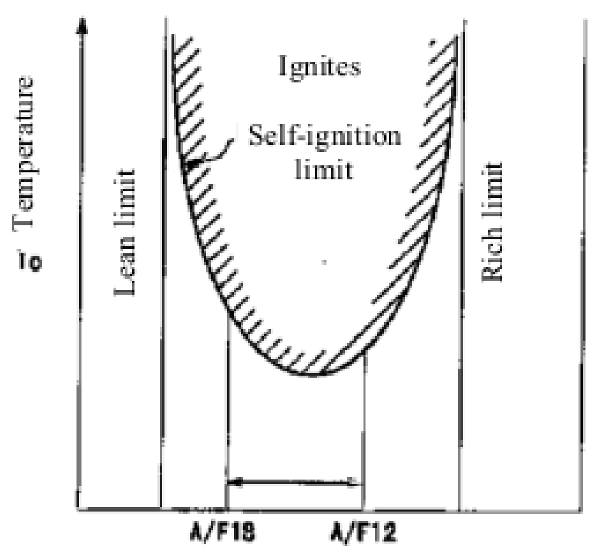
¶155. The knocking occurs in the zone where temperature and/or pressure are higher. *Id.*



In response to an increased tendency to knock, Kinjiro teaches increasing the air fuel ratio of the PI fuel by decreasing the amount of PI fuel and injecting a sufficient amount of DI fuel such that the "total air to fuel ratio is stoichiometric or rich." Ex. 1008, Claim 2, ¶¶[0009], [0041]; Ex. 1003, ¶156. To maintain the overall air to fuel ratio at stoichiometric or rich, as PI quantity decreases, DI quantity must increase. See Ex. 1008, ¶¶[0009], [0019]; Ex. 1003, ¶156. Thus, Kinjiro teaches that the ratio of DI fuel to PI fuel must increase with increasing cylinder temperature. Ex. 1003, ¶157.

Engine torque is directly related to the pressure in the cylinder, and thermodynamically, higher temperatures are associated with higher pressures. Ex. 1003, ¶157. For instance, in FIG. 6A below, Kinjiro shows that knocking can be avoided with a leaner PI fuel mixture as temperature increases. Ex. 1008, FIG. 6A, ¶[0008]; Ex. 1003, ¶157. The lean mixture in the cylinder is enriched with DI fuel to achieve a stoichiometric air/fuel ratio. Ex. 1008, ¶[0009]. As such, when the engine is operated at increased torque, increasing temperature and pressure is expected, and Kinjiro teaches in FIG. 6A that a leaner (higher air/fuel ratio) PI fuel mixture should be used at higher torque, requiring an increased ration of DI fuel to compensate for the leaner PI fuel mixture. *Id.*; Ex. 1003, ¶157.

(A) [FIG. 6]



3. Claim 1: [1.B] and wherein the engine is operated at a substantially stoichiometric fuel/air ratio.

Kinjiro discloses that its engine is operated such that "the overall air to fuel ratio is stoichiometric…." *See supra* §VII(C)(2); Ex. 1008, ¶[0009]; *see also* Ex. 1008, ¶¶[0008], [0014]-[0015], [0018]-[0019], [0039]; Ex. 1003, ¶¶158-60.

4. Claim 2: The spark ignition engine of claim 1 where the ratio of directly injected fuel to port injected fuel increases with increasing torque.

Kinjiro discloses increasing the ratio of DI fuel to PI fuel with increasing torque. *See supra* §VII(C)(2); Ex. 1008, FIGs. 5, 6A, 6B, ¶¶[0002], [0009], [0012], [0014], [0019], [0041]; Ex. 1003, ¶¶161-66.

5. Claim 3: The spark ignition engine of claim 2 where the ratio of directly injected fuel to port injected fuel is determined by a signal from a knock detector.

Kinjiro discloses a knock sensor, and information detected by the knock sensor is input to an ECU, which sets an operation control signal for each of the injectors 5 and 6. *See supra* §VII(C)(2); Ex. 1008, FIG. 5, ¶¶[0012], [0014], [0020]; Ex. 1003, ¶¶167-69. The knock detector determines whether the engine operates with port injection alone or with split injection and, in conjunction with the control system of Kinjiro that was described with respect to [1.A], thereby determines the ratio of directly injected fuel to port injected fuel. *See supra* §VII(C)(2).

6. Claim 4: The spark ignition engine of claim 3 further including a microprocessor that controls the ratio of the directly injected fuel to the port injected fuel based on the signal from the knock detector.

Kinjiro discloses a knock sensor, and information detected by the knock sensor is input to an ECU, which sets an operation control signal for each of the injectors 5 and 6. *See supra* §VII(C)(2); Ex. 1008, FIG. 5, ¶¶[0012], [0014], [0020]; Ex. 1003, ¶¶170-72. An ECU is an electronic controller and equivalent to a microprocessor. Ex. 1003, ¶170.

7. Claim 6: The spark ignition engine of claim 1 where the engine operates at a substantially stoichiometric fuel/air ratio at the highest loads.

"Highest loads" refers to the region of operation with the highest requirement for knock management. Ex. 1003, ¶173. As discussed with respect to Limitation 1.B, Kinjiro discloses that its engine operates at a substantially stoichiometric fuel/air ratio. *See supra* §VII(C)(3); Ex. 1008, ¶¶[0008]-[0009], [0014]-[0015], [0018]-[0019], [0039]; Ex. 1003, ¶¶174-76. Because Kinjiro discloses that the split injection mode is used when knock is detected, the Kinjiro engine employs a stoichiometric overall mixture under all split injection operating conditions, including at the highest loads. Ex. 1003, ¶176.

8. Claim 7: The spark ignition engine of claim 1 where the engine operates at some value of torque with port fuel injection alone.

Kinjiro discloses a torque range in which only PI is used. *See supra* §VII(C)(2); Ex. 1008, ¶¶[0014], [0020]; Ex. 1003, ¶177. Kinjiro recites:

> [T]his kind of split injection mode is implemented if it is determined by the ECU 10 that the engine 1 is in the specified operation state (that is, where knocking is occurring) based on detection information from the knock sensor 7, and furthermore, the engine 1 operates by general premixed combustion due to fuel injection from the main injector 5 during normal operation where knocking does not occur.

Ex. 1008, ¶[0020].

D. Ground 4: Claim 5 is unpatentable under pre-AIA 35 U.S.C. §103(a) over Kinjiro in view of Kobayashi

1. Overview of Ground 4

Independent claim 1 recites a spark ignition engine that uses DI and PI. The claim recites that the engine is operated at a substantially stoichiometric fuel/air ratio. The claim further recites that the ratio of DI to PI fuel increases above a selected torque value. Claim 5 depends from independent claim 1 and recites the use of open loop control to determine the ratio of DI to PI fuel.

i. Overview of Kinjiro and Kobayashi

Kinjiro is directed to a spark ignition engine that relies on both PI and DI for fueling an engine. Ex. 1008, ¶¶[0010]-[0011]; Ex. 1003, ¶180. Kinjiro discloses the use of DI for suppression of knock. Ex. 1008, Abstract, ¶[0014]; Ex. 1003, ¶180. In the split injection mode, Kinjiro discloses that its ECU determines the injection amount from each injector based on an air/fuel ratio and a specified operation state (e.g,, whether knock is occurring). Ex. 1008, ¶[0018]; Ex. 1003, ¶180. With respect to air/fuel ratio, Kinjiro discloses that the amount of DI fuel is based on the set air/fuel ratio of the engine and is changed based on the proportion of the total amount of PI fuel. Ex. 1008, Claim 2, ¶[0019]; Ex. 1003, ¶180. The POSITA would have understood that Kinjiro discloses transitioning from PI alone at low load conditions where knocking is unlikely to occur to split injection mode by directly injecting a proportion of the fuel at higher loads, where knocking is likely to occur. Ex. 1008, ¶¶[0020]-[0021]; Ex. 1003, ¶180. Kinjiro does not explicitly teach the use of open loop control in its engine operation. Ex. 1003, ¶181. However, a POSITA would have understood that closed loop control and open loop control where both well-known control mechanisms for controlling an engine, as illustrated by Kobayashi. *See id.*

Like Kinjiro, Kobayashi discloses the reliance on an ECU to control the operations of the engine. Ex. 1005, 10:16-17; Ex. 1003, ¶182. One particular function of the ECU is to detect the occurrence of knocking based on output from a knock sensor. Ex. 1005, 10:34-48; Ex. 1003, ¶182. Kobayashi discloses DI of hydrogen gas or other liquid fuel to reduce knock in response to the knock detector. Ex. 1005, 5:65-6:2; 11:57-64; Ex. 1003, ¶182. Kobayashi also discloses open loop control in at least FIG. 3. Ex. 1005, 11:29-31, 13:14-20; Ex. 1003, ¶182.

ii. Motivation to Combine

Kinjiro does not explicitly teach the use of open loop control in its engine operation. Ex. 1003, ¶181. However, a POSITA would have understood that closed loop control and open loop control where both well-known control mechanisms for controlling an engine. *See id.* In this way, a POSITA would have been motivated to modify Kinjiro based on Kobayashi, which discloses the use of a combination of closed loop control and open loop control, to suppress knock. *Id.* Kinjiro confirms the importance of using a knock sensor to supplement a pre-set fuel map given that a pre-set operating region may not account for operational variables or combinations thereof such as fuel octane, intake air temperature, engine temperature, or other factors that may influence a knock limit. Ex. 1008, ¶[0012]; Ex. 1003, ¶181.

Based on Kobayashi, a POSITA would have understood the benefits of using both open loop control and closed loop control. Ex. 1003, ¶183. Open loop control using a fuel map to establish an engine operating point at which DI is used to supplement PI is used to avoid engine knock. *See, e.g.*, Ex. 1005, 11:57-64; Ex. 1003, ¶183. Closed loop control using a knock detector further protects an engine from knock by taking countermeasures in the event knock is encountered. Ex.

1005, 5:65-6:2; 11:57-64; Ex. 1003, ¶183. A knock detector provides real time feedback from an engine and addresses a knock condition experienced by an engine, which can still occur despite using open loop control to avoid knock. Ex. 1003, ¶183.

Using open loop control, as taught by Kobayashi, reduces the likelihood that knock will be experienced by supplementing PI with DI under conditions that are prone to knocking, such as high load conditions. *Id*. Using closed loop control described by Kinjiro and Kobayashi provides knock reduction when knock is experienced, which may be caused by factors such as fuel octane, engine, coolant, or air temperatures, or the like, where the onset and degree of knocking due to these factors may be difficult to anticipate precisely. *Id*. Open loop control would not be expected to protect against knock given worst-case scenario conditions (e.g., very low quality/low octane fuel and high engine temperatures) unless the open loop control strategy was so cautious to avoid knock that it would undermine the efficiency of the engine. *Id*.

The POSITA would have also understood that relying on a knock sensor alone could result in reduced efficiency and output, as the system would be purely reactive and not proactive. *Id*. As such, it would be obvious to a POSITA to utilize both open loop control and closed loop control, as taught by Kobayashi. *Id*. Indeed, the POSITA would have understood that the use of a lookup table with a knock detector would provide the ability to achieve high engine efficiency with lower emissions, while protecting against knock or other damaging conditions. *Id*.

The use of open loop fuel maps in conjunction with feedback control from sensors was commonplace at the time the ’839 Patent was filed. Ex. 1003, ¶184. For example, open loop maps combined with feedback control from oxygen sensors were used to manage air/fuel ratio in PI vehicles at the time the ’839 Patent was filed. *See, e.g.*, Ex. 1028, 1:31; Ex. 1003, ¶184. As a result, the POSITA would have relied on open loop control, as disclosed in Kobayashi, in combination with the closed loop control (e.g., knock sensor) of Kinjiro. Ex. 1003, ¶184.

The POSITA would have had a reasonable expectation of success given that both Kinjiro and Kobayashi rely on the use of PI and DI at high loads. Ex. 1003, ¶185. As such, the POSITA would have understood that inclusion of the lookup table of Kobayashi with the teachings of Kinjiro would have been a straightforward modification that would have a reasonable expectation of success. *Id.* Indeed, such a modification was simply the addition of a well-known lookup table to the engine of Kinjiro. *Id.*

2. Claim 5: The spark ignition engine of claim 2 where open loop control is used to determine the ratio of the directly injected fuel to the port injected fuel.

Kinjiro discloses a knock sensor, and information detected by the knock sensor is input to an ECU, which sets an operation control signal for each of the injectors 5 and 6. *See supra* §VII(C)(2); Ex. 1008, FIG. 5, ¶¶[0012], [0014]; Ex. 1003, ¶186. Kinjiro is silent on open loop control. Ex. 1003, ¶186. However, a POSITA would have understood that relying on a knock sensor alone could result in reduced efficiency and output, as the system would be purely reactive and not proactive. *Id.* As such, it would be obvious to a POSITA to supplement the closed loop control of Kinjiro with the open loop control of Kobayashi. *Id.*

Kobayashi discloses the use of a combination of closed loop control and open loop control to suppress knock. Ex. 1003, ¶187. Specifically, Kobayashi discloses the reliance on an ECU to control the operations of the engine. Ex. 1005, 10:16-17; Ex. 1003, ¶187. One particular function of the ECU is to detect the occurrence of knocking based on output from a knock sensor. Ex. 1005, 10:34-48; Ex. 1003, ¶187. Kobayashi discloses DI of hydrogen gas or other liquid fuel to reduce knock in response to the knock detector. Ex. 1005, 5:65-6:2, 11:57-64; Ex. 1003, ¶187.

Kobayashi discloses open loop control in at least FIG. 3. *See also* Ex. 1005, 11:29-31; 13:14-20; Ex. 1003, ¶187. Specifically, Kobayashi discloses "FIG. 3 is a flowchart showing an engine operation control routine executed by the ECU 30." Ex. 1005, 11:29-31. Further, S106 of Figure 3 "determine fuel injection quantity and intake air quality" would rely on a lookup table (e.g., a corresponding map).

Ex. 1005, 13:14-20. Moreover, in S112, the discriminator for determining high load conditions would likewise rely on a lookup table.

Based on Kobayashi, a POSITA would have understood the benefits of using both open loop control and closed loop control. Ex. 1003, ¶188. Open loop control using a fuel map to establish an engine operating point at which DI is used to supplement PI is used to avoid engine knock. *See, e.g.*, Ex. 1005, 11:57-64; Ex. 1003, ¶188. Closed loop control using a knock detector further protects an engine from knock by taking countermeasures in the event knock is encountered. Ex. 1005, 5:65-6:2; 11:57-64; Ex. 1003, ¶188. Indeed, a knock detector provides real time feedback from an engine and addresses a knock condition experienced by an engine, which can still occur despite using open loop control to avoid knock. Ex. 1003, ¶188. Using open loop control reduces the likelihood that knock will be experienced by supplementing PI with DI under conditions that are prone to knocking, such as high load conditions. *Id.* Using closed loop control provides knock reduction when knock is experienced, which may be caused by factors such as fuel octane, engine, coolant, or air temperatures, or the like. *Id.* Open loop control would not be expected to protect against knock given worst-case scenario conditions (e.g., very low quality/low octane fuel and high engine temperatures) unless the open loop control strategy was so cautious to avoid knock that it would undermine the efficiency of the engine. *Id.* As such, it would be apparent to a

POSITA to utilize both open loop control and closed loop control, as taught by Kobayashi. *Id.* Indeed, the POSITA would have understood that the use of a lookup table with a knock detector would provide the ability to achieve high engine efficiency with lower emissions, while protecting against knock or other damaging conditions. *Id.*

A. <u>Ground 5: Claims 1-5 and 8 are unpatentable under pre-AIA 35 U.S.C. §103(a) over Rubbert in view of Bosch</u>

1. Overview of Ground 5

Independent claim 1 recites a spark ignition engine that uses DI and PI. The claim recites that the engine is operated at a substantially stoichiometric fuel/air ratio. The claim further recites that the ratio of DI to PI fuel increases above a selected torque value.

i. Overview of Rubbert and Bosch

Rubbert discloses a dual injection, load dependent, spark ignited engine. *See generally* Ex. 1007; Ex. 1003, ¶194. Rubbert teaches a larger quantity of PI fuel at low loads and a larger quantity of DI fuel at high loads. Ex. 1007, 1:49-2:8; Ex. 1003, ¶194. Rubbert explains the dual injector technology and operation in a concise and succinct manner; however, Rubbert is silent regarding control systems and using a substantially stoichiometric fuel/air ratio. Ex. 1003, ¶194. Rubbert's silence would not be surprising to the POSITA given that control systems and the use of a stoichiometric fuel/air ratio were ubiquitous in the field of spark ignition engines, which is illustrated by Bosch. *Id.*

Bosch, a commonly used automotive handbook, discloses the mechanics of spark ignition engines, including various control and operating systems, along with explanations as to why a POSITA would rely on such systems. Ex. 1003, ¶196. Specifically, Bosch teaches the use of a stoichiometric fuel/air ratio in spark ignition engines. Ex. 1031, 478; Ex. 1003, ¶196. The stoichiometric mixture is required for the three-way catalyst, and Bosch teaches that major industrial nations had adopted the three-way catalyst at the time of publication. Ex. 1031, 479; Ex. 1003, ¶196. Bosch illustrates that the performance of a three-way catalyst depends on a stoichiometric fuel/air ratio. Ex. 1031, 481; Ex. 1003, ¶196.[6]

Bosch also teaches various control systems for spark ignition engines. Ex. 1003, ¶197. With regard to closed loop control, Bosch discloses a "knock sensor that monitors structure-borne noise, which it transforms into an electrical signal suitable for transmission to the ECU." Ex. 1031, 464. Further, "[t]he (closed-loop)

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[6] Patent Owner asserts "Ford vehicles equipped with the Accused Instrumentalities utilize what are known in the industry as 'three way' catalytic converters, which are understood in the industry to ensure that an engine is operating at a stoichiometric fuel/air ratio." Ex. 1036, 3.

control circuit adjusts the engine by means of an actuator and eliminates the knock." Ex. 1031, 465. With regard to open loop control, Bosch teaches that "[o]pen-loop control systems feature processes in which one or several input variable are employed for adjustments to one or several output variables." Ex. 1031, 164. Bosch further teaches that "[a]n open control loop can be a subordinate part of another system, and can interact in any fashion with other systems." *Id*.

ii. Motivation to Combine

Rubbert is silent regarding control systems and using a substantially stoichiometric fuel/air ratio. Ex. 1003, ¶194. Rubbert's silence would not be surprising to the POSITA given that control systems and the use of a stoichiometric fuel/air ratio were ubiquitous in the field of spark ignition engines. *Id.* Indeed, many of the details required to implement Rubbert's invention would be known by the POSITA. *Id.* These details would include PI and DI control to deliver fuel in a manner that promotes desirable traits such as good driveability and high efficiency in operating the engine. *Id.*

Given that Rubbert explicitly discloses a spark ignition engine, a POSITA would have understood the general concepts involved in such a spark ignition engine, including control and operating systems. Ex. 1003, ¶195. For at least this reason, a POSITA would have been motivated to implement well-known control and operating systems, including open loop control and closed loop control and the use of a stoichiometric air/fuel ratio. *Id.*

Bosch teaches the use of a stoichiometric fuel/air ratio in spark ignition engines. Ex. 1031, 478; Ex. 1003, ¶196. The stoichiometric mixture is required for the three-way catalyst, and Bosch teaches that major industrial nations had adopted the three-way catalyst at the time of publication. Ex. 1031, 479; Ex. 1003, ¶196. Bosch illustrates that the performance of a three-way catalyst depends on a stoichiometric fuel/air ratio. Ex. 1031, 481; Ex. 1003, ¶196.[7]

Bosch also teaches various control systems for spark ignition engines. Ex. 1003, ¶197. With regard to closed loop control, Bosch discloses a "knock sensor that monitors structure-borne noise, which it transforms into an electrical signal suitable for transmission to the ECU." Ex. 1031, 464. Further, "[t]he (closed-loop) control circuit adjusts the engine by means of an actuator and eliminates the knock." Ex. 1031, 465. With regard to open loop control, Bosch teaches that "[o]pen-loop control systems feature processes in which one or several input

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[7] Patent Owner asserts "Ford vehicles equipped with the Accused Instrumentalities utilize what are known in the industry as 'three way' catalytic converters, which are understood in the industry to ensure that an engine is operating at a stoichiometric fuel/air ratio." Ex. 1036, 3.

variable are employed for adjustments to one or several output variables." Ex. 1031, 164. Bosch further teaches that "[a]n open control loop can be a subordinate part of another system, and can interact in any fashion with other systems." *Id*.

A POSITA would have understood that open loop control or closed loop control could have been applied to the management of other engine variables that influence knock, including quantity of direct fuel injection as disclosed by Rubbert. Ex. 1003, ¶198. Similarly, a POSITA would have understood that spark ignition engines commonly operated at a stoichiometric air/fuel ratio. *Id*. As such, given the ubiquitous nature of the various control and operating systems in spark ignition engines, a POSITA would have had a reasonable expectation of success and would have expected a predicable result, including, for example, the reduction in knock. *Id*.

2. *Claim 1: [1.Pre] A spark ignition engine that is fueled both by direct injection and by port injection*

The preamble of a claim is generally not limiting for the reasons set forth with respect to Claim 1 in Ground 1. *See supra* §VII(A)(1).

To the extent the preamble of Claim 1 is limiting, Rubbert discloses a spark ignited internal combustion engine that relies on a "combination of a port injection with a direct injection through respective, load-dependent controlled/regulated partial injection quantities." Ex. 1007, 1:3-5, 1:31-34; Ex. 1003, ¶200. Rubbert discloses that in the idling and partial load ranges, the greater portion of fuel in the mixture is injected by induction pipe injection (*e.g.*, PI) than by DI and in the full or high load range, the fuel portion in the mixture can be mostly or completely DI. Ex. 1007, 1:49-2:8; Ex. 1003, ¶200. Rubbert relies on DI for advantages related to cylinder filling and knock reduction. Ex. 1007, 2:4-8; Ex. 1003, ¶200.

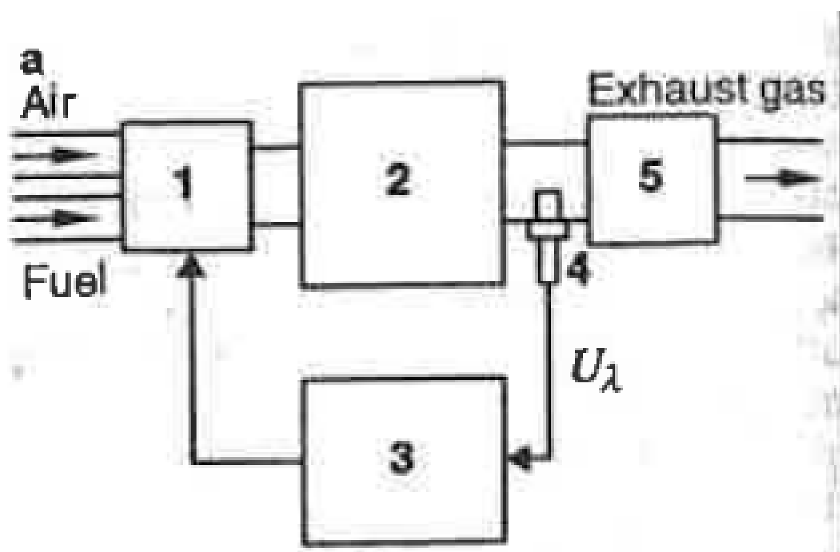
3. Claim 1: [1.A] wherein above a selected torque value the ratio of fuel that is directly injected to fuel that is port injected increases;

Rubbert discloses that in the idling and partial load ranges, the greater portion of fuel in the mixture is PI fuel and in the full or high load range, the fuel portion in the mixture can be mostly or completely DI fuel. *See supra* §VII(E)(2); Ex. 1007, 1:49-2:8; Ex. 1003, ¶201. In this regard, Rubbert discloses that the ratio of DI to PI fuel increases above a certain load value, *i.e.* the threshold between the low load range and the high load range. Ex. 1003, ¶201.

4. Claim 1: [1.B] and wherein the engine is operated at a substantially stoichiometric fuel/air ratio.

Rubbert discloses a spark ignited internal combustion engine that relies on a "combination of a port injection with a direct injection through respective, load-dependent controlled/regulated partial injection quantities." *See supra* §VII(E)(2); Ex. 1007, 1:3-5, 1:31-34; Ex. 1003, ¶202. Rubbert, however, is silent regarding a substantially stoichiometric fuel/air ratio. Ex. 1003, ¶202. Rubbert's silence would not be surprising to the POSITA given that operation at a stoichiometric fuel/air ratio is ubiquitous in the field of spark ignition engines. *Id.* Bosch, however, teaches the use of a stoichiometric fuel/air ratio in spark ignition engines. *Id.*

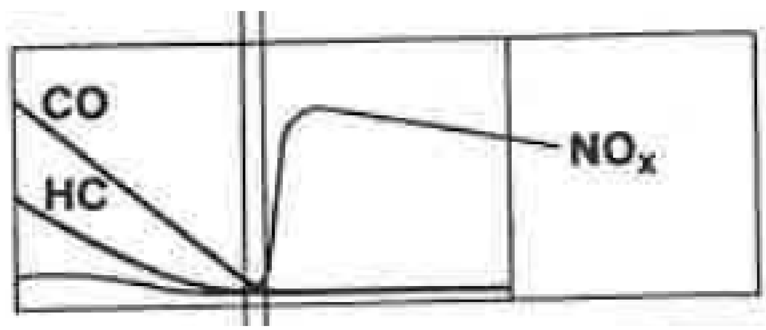
Bosch discloses an ECU that is substantially similar to the fuel management microprocessor of the ’839 Patent. FIG. 1 of the ’839 Patent presents a fuel management microprocessor that manages the injection of both fuels. Ex. 1001, FIG. 1; Ex. 1003, ¶203. However, the ECU functions are not (and the claims are certainly not) limited to those shown in FIG. 1. Ex. 1003, ¶203. Bosch presents a figure (below) with an ECU 3 that controls fueling to an engine in closed loop. Ex. 1031, 482; Ex. 1003, ¶203.



Bosch further presents spark control by an ECU with knock sensor integration. Ex. 1031, 463-64; Ex. 1003, ¶203. A POSITA would appreciate that Bosch’s figures represent multiple functions of a single ECU. Ex. 1003, ¶203.

Bosch presents additional detail on controlling fuel/air ratio control using an integrated ECU 18. Ex. 1031, 440; Ex. 1003, ¶204. Bosch also describes the integration of a lambda (fuel/air ratio) sensor with the ECU. Ex. 1031, 441; Ex. 1003, ¶204. Bosch teaches that the lambda (fuel/air ratio) control supports a catalytic converter, which requires a stoichiometric fuel/air ratio for operation. Ex. 1031, 113, 482; Ex. 1003, ¶204.

Furthermore, Bosch teaches confirms that spark ignited engines run on a stoichiometric mixture whereas diesel engines run in a lean mode. Ex. 1031, 478; Ex. 1003, ¶205. The stoichiometric mixture is required for the three-way catalyst, and Bosch teaches that major industrial nations had adopted the three-way catalyst at the time of publication. Ex. 1031, 479; Ex. 1003, ¶205. Bosch shows in a figure (below) that the performance of a three-way catalyst depends on a stoichiometric fuel/air ratio (lambda value of 1). Ex. 1031, 481; Ex. 1003, ¶205.



Patent Owner confirmed this understanding in the litigation, noting that "'three way' catalytic converters…are understood in the industry to ensure that an engine is operating at a stoichiometric fuel/air ratio." Ex. 1036, 3. Based on Bosch, a

POSITA would understand that a spark ignited engine, such as the Rubbert engine, would be operated with a substantially stoichiometric mixture. Ex. 1003, ¶205.

5. *Claim 2: The spark ignition engine of claim 1 where the ratio of directly injected fuel to port injected fuel increases with increasing torque.*

Rubbert discloses that in the idling and partial load ranges, the greater portion of fuel in the mixture is PI fuel and in the full or high load range, the fuel portion in the mixture can be mostly or completely DI fuel. *See supra* §VII(E)(2); Ex. 1007, 1:49-2:8. As such, Rubbert discloses transitioning from PI-dominated fueling to DI-dominated fueling as load increases. *See supra* §VII(E)(3); Ex. 1007, 1:49-2:8; Ex. 1003, ¶206. In this regard, Rubbert discloses that the ratio of DI to PI fuel increases as torque increases. Ex. 1003, ¶206.

6. *Claim 3: The spark ignition engine of claim 2 where the ratio of directly injected fuel to port injected fuel is determined by a signal from a knock detector.*

Rubbert is silent regarding the use of a knock sensor to control the direct fuel injection, but the POSITA would understand that knock sensors were known and commonly used to control knock. Ex. 1003, ¶207. Indeed, knock sensors were common in spark ignition engines at the time of the '839 Patent and even much earlier. *Id.*

For example, Bosch discloses that knock sensors are used to prevent knock in internal-combustion engines by adjusting the engine by means of an actuator.

Ex. 1031, 464-65; Ex. 1003, ¶208. Bosch teaches that the knock sensor "monitors structure-borne noise, which it transforms into an electrical signal suitable for transmission to the ECU." Ex. 1031, 464. Using the information from the knock sensor, "[t]he (closed loop) control circuit adjusts the engine by means of an actuator and eliminates the knock." Ex. 1031, 465. Bosch provides that one such actuator may include ignition timing, but was not limited to such, and a POSITA would have understood that the actuator could have been used with any anti-knock measure, including the direct fuel injection of Rubbert. Ex. 1003, ¶208. Accordingly, a POSITA would have understood Bosch to teach the use of a knock sensor to control the direct fuel injection of Rubbert. Ex. 1003, ¶208.

7. *Claim 4: The spark ignition engine of claim 3 further including a microprocessor that controls the ratio of the directly injected fuel to the port injected fuel based on the signal from the knock detector.*

The combination of Rubbert and Bosch discloses a knock detector that communicates with an ECU to determine and control the ratio of DI to PI fuel. *See supra* §VII(E)(6); Ex. 1007, 1:3-5, 31-34; Ex. 1003, ¶¶210-12. A POSITA would understand that an ECU is an electronic controller and equivalent to a microprocessor. Ex. 1003, ¶209.

8. Claim 5: The spark ignition engine of claim 2 where open loop control is used to determine the ratio of the directly injected fuel to the port injected fuel.

Rubbert discloses that in the idling and partial load ranges, the greater portion of fuel in the mixture is PI fuel and in the full or high load range, the fuel portion in the mixture can be mostly or completely DI fuel. *See supra* §VII(E)(2); Ex. 1007, 1:49-2:8; Ex. 1003, ¶201. However, Rubbert is silent regarding the use of open loop control, but the POSITA would understand that open loop control is commonly used to manage all or part of fueling during engine operation. Ex. 1003, ¶213. Indeed, open loop control was common technology at the time of the ’839 Patent and even much earlier. *Id.*

Moreover, to the extent that open loop control is not explicitly disclosed by Rubbert, it is explicitly disclosed by Bosch. Ex. 1003, ¶214. For instance, Bosch teaches that "[o]pen-loop control systems feature processes in which one or several input variable are employed for adjustments to one or several output variables." Ex. 1031, 164. Bosch further teaches that "[a]n open control loop can be a subordinate part of another system, and can interact in any fashion with other systems." *Id*. In one example of an open loop control system, Bosch teaches that ignition point (e.g., spark retard) can be controlled based on variables including engine speed, intake-manifold pressure, and engine temperature. Ex. 1031, 167; Ex. 1003, ¶214. Bosch teaches that fueling may also be controlled by an ECU in either closed loop or open loop control. Ex. 1031, 441; Ex. 1003, ¶214. Bosch teaches that a coding switch allows selection between lambda control (closed loop) for use with a catalyst and no lambda control (open loop) for use without a catalyst. *Id*. It would have been obvious to a POSITA to modify Rubbert to include open loop control as discussed by Bosch in order to maintain additional control over engine variables, including ignition point. Ex. 1003, ¶214.

9. Claim 8: The spark ignition engine of claim 1 where the engine operates at some value of torque with direct injection alone.

Rubbert relies on DI for advantages related to cylinder filling and knock reduction Ex. 1007, 2:4-8; Ex. 1003, ¶215. Rubbert discloses that in the full or high load range, the fuel portion in the mixture can be mostly or ***completely*** injected by direct injection. *Id*.

B. No Ground is Redundant

There is no redundancy in this petition because it applies references in combination and to complement each other, rather than as distinct and separate alternatives. Specifically, Ground 1 challenges Claims 1, 2, and 5-8 based on Takehiko alone. Ground 2 illustrates the elements of Claims 3 and 4 based on Takehiko and Kobayashi, which illustrates that the concept of adding closed loop control to an engine using open loop control was known in spark ignition engines. Ground 3 challenges Claims 1-4, 6 and 7 based on Kinjiro alone, further illustrating the known use of closed loop control in a spark ignition engine. Ground 4 challenges Claim 5 based on Kinjiro and Kobayashi, which illustrates the use of open loop control in an engine designed for closed loop control. Finally, Ground 5 challenges Claims 1-5 and 8 based on Rubbert and Bosch, which illustrates that the generic concept of PI and DI was known in spark ignition engines.

VIII. CONCLUSION

Petitioner respectfully requests the Board to institute a trial and cancel Claims 1-8 of the ’839 Patent.

IX. MANDATORY NOTICES UNDER 37 C.F.R. §42.8

A. Real Party in Interest Under 37 C.F.R. §42.8(b)(1)

The real party-in-interest is Petitioner, Ford Motor Company.

B. Related Matters Under 37 C.F.R. §42.8(b)(2)

A claim of infringement of U.S. Patent No. 8,069,839 (“the ’839 Patent”) was asserted in *Ethanol Boosting Systems, LLC et al v. Ford Motor Company, LLC*, Case No. 1:19-cv-00196-CFC (Del. Dist. Ct.), filed on January 30, 2019.

Petitioner is simultaneously filing petitions for IPR of related U.S. Patent No. 9,810,166 under the case heading IPR2019-01399; U.S. Patent No. 9,255,519 under the case heading IPR2019-01401; and U.S. Patent No. 10,138,826 under the case heading IPR2019-01402.

As recited in the ’839 Patent, the ’839 Patent is a continuation of U.S. patent application Ser. No. 12/815,842, filed Jun. 15, 2010, which is now issued as U.S.

Pat. No. 7,971,572, which is a continuation of U.S. patent application Ser. No. 12/329,729 filed on Dec. 8, 2008, which is now issued as U.S. Pat. No. 7,762,233, which is a continuation of U.S. patent application Ser. No. 11/840,719 filed on Aug. 17, 2007, which is now issued as U.S. Pat. No. 7,740,004, which is a continuation of U.S. patent application Ser. No. 10/991,774, which is now issued as U.S. Pat. No. 7,314,033.

Finally, Petitioner is aware of at least two U.S. patent applications 16/251,658 and 16/424,471, which claim priority to the same application to which the '839 Patent claims priority.

C. Designation of Counsel Under 37 C.F.R. §42.8(b)(3)

Petitioner provides the following designation of counsel.

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Pursuant to 37 C.F.R §42.10(b), a Power of Attorney is being submitted with this Petition.

D. Service Information

Please address all correspondence and service to the address listed above. Petitioner consents to electronic service directed to christopher.douglas@alston.com and Ford-EBS@alston.com.

Date: August 13, 2019

By: /Christopher TL Douglas/
Christopher TL Douglas

CERTIFICATION UNDER 37 C.F.R. §42.24

Under the provisions of 37 CFR §42.24, the undersigned hereby certifies that the word count for the foregoing Petition for *inter partes* review totals 11,841 words (Sections I-VIII), which is less than the 14,000 allowed under 37 CFR §42.24(a)(i).

Date: August 13, 2019

By: /Christopher TL Douglas/
Christopher TL Douglas

CERTIFICATE OF SERVICE

Pursuant to 37 C.F.R. §§42.6(e), 42.105, the undersigned hereby certifies service on the Patent Owner of a copy of this Petition and its respective exhibits to Patent Owner via UPS Next Day Air on the correspondence address of record in PAIR for U.S. Patent No. 8,069,839 as follows:

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Cambridge MA 02142-1493

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Date: August 13, 2019

By: /Christopher TL Douglas/
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EXHIBIT 9

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

FORD MOTOR COMPANY

Petitioner

v.

ETHANOL BOOSTING SYSTEMS, LLC, and MASSACHUSETTS INSTITUTE OF TECHNOLOGY,

Patent Owner

Case: IPR2019-01399

U.S. Patent No. 9,810,166

PETITION FOR *INTER PARTES* REVIEW UNDER 35 U.S.C. §312 AND 37 C.F.R. §42.104

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US Patent and Trademark Office
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LIST OF EXHIBITS

Exhibit	Short Name	Description
Ex. 1001	’166 Patent	U.S. Patent No. 9,810,166
Ex. 1002	’166 File History	File History of U.S. Patent No. 9,810,166
Ex. 1003	Clark Declaration	Declaration of Dr. Nigel N. Clark under 37 C.F.R. §1.68
Ex. 1004	Clark CV	*Curriculum Vitae* of Dr. Nigel N. Clark
Ex. 1005	Kobayashi	U.S. Patent No. 7,188,607
Ex. 1006	Yuushiro	Japanese Patent Application Publication No. JPH10252512
Ex. 1007	Rubbert	German Patent Application No. DE19853799
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Ex. 1010	’784 File History	File History of U.S. Patent No. 9,695,784
Ex. 1011	’519 File History	File History of U.S. Patent No. 9,255,519
Ex. 1012	’410 File History	File History of U.S. Patent No. 8,857,410
Ex. 1013	’321 File History	File History of U.S. Patent No. 8,733,321
Ex. 1014	’746 File History	File History of U.S. Patent No. 8,522,746
Ex. 1015	’580 File History	File History of U.S. Patent No. 8,302,580
Ex. 1016	’568 File History	File History of U.S. Patent No. 8,146,568
Ex. 1017	’839 File History	File History of U.S. Patent No. 8,069,839
Ex. 1018	’572 File History	File History of U.S. Patent No. 7,971,572

Exhibit	Short Name	Description
Ex. 1019	’233 File History	File History of U.S. Patent No. 7,762,233
Ex. 1020	’004 File History	File History of U.S. Patent No. 7,740,004
Ex. 1021	’033 File History	File History of U.S. Patent No. 7,314,033
Ex. 1022	Complaint	Complaint for Patent Infringement, *Ethanol Boosting Sys LLC v. Ford Motor Co.*, D.I. 1, C.A. No. 19-cv-196-CFC (D. Del. Jan. 30, 2019)
Ex. 1023	Defendant’s Answer	Defendant’s Answer, Defenses, Counterclaims and Jury Demand, *Ethanol Boosting Sys LLC v. Ford Motor Co.*, D.I. 1, C.A. No. 19-cv-196-CFC (D. Del. March 25, 2019)
Ex. 1024	Plaintiff’s Answer	Answer to Defendant’s Counterclaims, *Ethanol Boosting Sys LLC v. Ford Motor Co.*, D.I. 1, C.A. No. 19-cv-196-CFC (D. Del. April 15, 2019)
Ex. 1025	Heywood	John B. Heywood, *Internal Combustion Engine Fundamentals* (1988)
Ex. 1026	’735 File History	File History of U.S. Patent No. 8,082,735
Ex. 1027	’157 File History	File History of U.S. Patent Application No. 11/758,157
Ex. 1028	RESERVED	RESERVED
Ex. 1029	RESERVED	RESERVED
Ex. 1030	’717 File History	File History of U.S. Patent Application No. 13/591,717
Ex. 1031	Bosch	Bosch Automotive Handbook (3rd Ed.)

Exhibit	Short Name	Description
Ex. 1032	Stokes	J. Stokes et al. "A gasoline engine concept for improved fuel economy—the lean-boost system," SAE paper 2000-01-2902, 1-12
Ex. 1033	RESERVED	RESERVED
Ex. 1034	Csere	Csere, C. "A Smarter Way to use Ethanol to Reduce Gasoline Consumption," (2007), https://www.caranddriver.com/features/a15147006/a-smarter-way-to-use-ethanol-to-reduce-gasoline-consumption/
Ex. 1035	'100 File History	File History of U.S. Patent Application No. 15/463,100
Ex. 1036	'166 Infringement Contentions	MIT's/EBS's Preliminary Infringement Chart (Ex. C – U.S. Patent No. 9,810,166), *Ethanol Boosting Sys LLC v. Ford Motor Co.*, D.I. 35, C.A. No. 19-cv-196-CFC (D. Del. July 1, 2019)
Ex. 1037	Mullins Declaration	Declaration of Dr. James L. Mullins under 37 C.F.R. §1.68
Ex. 1038	Mullins CV	*Curriculum Vitae* of Dr. James L. Mullins
Ex. 1039	'839 Infringement Contentions	MIT's/EBS's Preliminary Infringement Chart (Ex. A – U.S. Patent No. 8,069,839), *Ethanol Boosting Sys LLC v. Ford Motor Co.*, D.I. 35, C.A. No. 19-cv-196-CFC (D. Del. July 1, 2019)

Ford Motor Company ("Petitioner") petitions for *Inter Partes* Review ("IPR") under 35 U.S.C. §§311–319 and 37 C.F.R. §42 of Claims 1-5, 7, 8, 10-24, and 26-30 ("the challenged claims") of U.S. Patent No. 9,810,166 ("the '166 Patent"). Petitioner requests cancellation of the challenged claims.

I. GROUNDS FOR STANDING UNDER 37 C.F.R. §42.104(a)

Petitioner certifies that the '166 Patent is available for IPR and that Petitioner is not barred or estopped from requesting an IPR.

II. PAYMENT OF FEES

Petitioner authorizes Account No. 16-0605 to be charged for any additional fees.

III. OVERVIEW OF CHALLENGES AND RELIEF REQUESTED

Pursuant to Rules 42.22(a)(1) and 42.104(b)(1)–(2), Petitioner requests cancellation of the challenged claims in view of the grounds set forth below. This petition provides details on claim construction and where each element is found in the cited prior art. Additional support is provided in Ex. 1003–Declaration of Nigel Clark ("Clark"). ¶9 *et seq*.

Ground 1: Claims 1-5, 7, 8, 10, and 14-21 are unpatentable under pre-AIA 35 U.S.C. §103(a) over Kobayashi in view of Yuushiro.

Ground 2: Claims 1-5, 7, 8, 10-24, and 26-30 are unpatentable under pre-AIA 35 U.S.C. §103(a) over Rubbert in view of Yuushiro and Bosch.

Ground 3: Claims 1-5, 7, 8, 10-24, and 26-30 are unpatentable under pre-AIA 35 U.S.C. §103(a) over Kinjiro in view of Bosch.

IV. BACKGROUND

A. The ’166 Patent

The ’166 Patent describes an engine that relies on an antiknock agent to eliminate knock, with the antiknock agent being a liquid fuel with a higher octane number than gasoline (e.g., ethanol) to improve engine efficiency. Ex. 1001, 1:35-38, 2:23-39; Ex. 1003, ¶¶35-39.

B. ’166 Patent Prosecution History

The ’166 Patent was granted from the thirteenth in a family of U.S. patent applications. These U.S. applications are continuations of U.S. Application No. 10/991,774 (“the ’774 Application”), filed November 18, 2004.

In the only Office Action, the Examiner rejected Claims 22-30 under 35 U.S.C. §102(e) as being anticipated by U.S. Pub. No. 2005/0098157 (“Ohtani”). The Examiner also rejected Claims 1-30 on nonstatutory double patenting. Ex. 1002, 53-55. In response, Patent Owner amended the claims and argued that Ohtani decreases the fraction of fuel provided by direct injection (“DI”) in order to prevent a combustion deterioration rather than knock, and that spark retard would worsen combustion deterioration. Ex. 1002, 82.

C. Priority Date

As discussed above, the ’166 Patent ultimately claims the benefit of the ’774 application, filed on November 18, 2004. The challenged claims, however, are not entitled to the priority applications’ priority date because their disclosures do not demonstrate Patent Owner was in possession of the alleged claimed invention. *See Dynamic Drinkware, LLC v. Nat’l Graphics, Inc.*, 800 F.3d 1375, 1380 (Fed. Cir. 2015).

D. <u>Claim Construction (37 C.F.R. §42.104(b)(3))</u>

Claim terms are interpreted according to the same claim construction standard used in a civil action under 35 U.S.C. §282(b), including construing the claim in accordance with the ordinary and customary meaning as understood by a person of ordinary skill in the art (“POSITA”) under *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005) and its progeny. Petitioner reserves all rights to take different positions with respect to claim construction in any other proceeding.

1. “Torque Range” / “Range of Torque” / “Region of Torque”

The terms “torque range,” “range of torque,” and “region of torque” (“torque range”) are used throughout the challenged claims to define at least a first torque range whereby an engine uses port fuel injection (“PI”) and DI, and a second torque range where PI alone is used. *See, e.g.*, Ex. 1001, Claim 19; Ex. 1003, ¶140.

The claims define torque ranges based on whether the engine utilizes (1) PI only or (2) PI and DI. Ex. 1003, ¶140. As such, the "torque range" terms are undefined.[1]

"Torque range" never appears in the '166 Patent specification.[2] For the purposes of this proceeding only, a POSITA, however, would have understood that torque is a measure of the work performed by the engine, and engine load is a proportional indicator of torque in the range from minimum torque to maximum torque. Ex. 1003, ¶142. A POSITA would have further understood that where the torque range on a torque-speed map lies between a first specified value of torque and a second specified value of torque, similarly the load range would lie between a first percentage of load and a second percentage of load. *Id.* A POSITA would understand that a "torque range" is a range of values representative of engine load. *Id.* A POSITA would have equated moving from one torque range to a different torque range, to moving from one region of a load map to a different region of a load map. *Id.*

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[1] Petitioner reserves the right to assert relevant 35 U.S.C. §112 challenges in the litigation.

[2] The Patent Office confirmed that the term "torque range" was missing from the specification. Ex. 1035, 187-88.

Patent Owner confirms this interpretation. Patent Owner relies on engine load and/or RPM as a proxy for the "torque range" terms. Patent Owner states: "For example, it has been reported that, at ***certain rpm/engine load ranges (i.e., torque)***, such fuel management system utilize [*sic*] both PFI and DI." Ex. 1036, 1 (emphasis added). Patent Owner further states: "Knock is a significant issue at moderate-to-high loads (***also known as torques***)." Ex. 1036, 2 (emphasis added).

Accordingly, Petitioner adopts Patent Owner's construction that "torque range" should be construed to equate to "load range." Moreover, Petitioner proposes that the "torque range" terms mean "the region on a torque-speed map that lies between a first specified value of torque and a second specified value of torque," consistent with the ordinary and customary meaning of the term. Ex. 1003, ¶¶142-43.

2. "Port Fuel Injection" / "Direct Injection"

Petitioner also advances a construction of "port fuel injection," "direct injection," and variants thereof. "Port fuel injection" should be construed to mean "injection of fuel through a manifold," and "direct injection" should be construed to mean "injection of fuel into the cylinder," consistent with their respective ordinary and customary meanings. Ex. 1003, ¶144. In construing these terms, Petitioner adopts Patent Owner's construction and does not limit the type of PI or DI fuel used. *Id*. ¶¶144-49.

The claims themselves do not recite the actual fuel(s) injected. Ex. 1003, ¶144. The specification, however, discloses, and limits the ’166 Patent to, two distinct fuel sources, a gasoline tank and a tank containing an antiknock agent (e.g., ethanol). Ex. 1001, FIG. 1; Ex. 1003, ¶145. The ’166 Patent appears to use the term “antiknock agent” to describe a different fuel than the PI fuel and, further, uses “antiknock agent” to describe fuels such as ethanol, methanol, etc. Ex. 1001, 2:23-30; Ex. 1003, ¶145. Regardless, the ’166 Patent identifies DI of ethanol as the object of the present invention.[3] Ex. 1001, 2:11-13; Ex. 1003, ¶146.

Despite the disclosures in the specification and the ’033 Patent prosecution history (Ex. 1021, 88-90, 129), in the litigation Patent Owner is asserting its claims against certain Ford EcoBoost engines, which are known to use a single fuel, e.g., gasoline, where the same single fuel is used by both the PI and DI system. Ex. 1022, ¶87; Ex. 1003, ¶149. Accordingly, Petitioner adopts Patent Owner’s construction for purposes of this proceeding and the challenged claims should be construed to be broad enough to include a system using DI and PI of the same fuel from the same fuel source. Ex. 1003, ¶149. Petitioner’s construction of “port fuel injection” as meaning “injection of fuel through a manifold,” and “direct injection”

[3] Petitioner reserves the right to assert that the claims are limited to the direct injection of an antiknock agent alone, such as ethanol.

as meaning "injection of fuel into the cylinder" without further limiting the fuel identity fuel is consistent with Patent Owner's implicit construction.

V. PRIOR ART REFERENCES

A. U.S. Patent No. 7,188,607 ("Kobayashi")

Kobayashi was filed June 27, 2003, in the United States and issued March 13, 2007. Kobayashi is prior art under at least pre-AIA 35 U.S.C. §102(e)(1) if the claims are deemed entitled to a priority date of November 18, 2004. Kobayashi is cited on the face of the '166 Patent but was not relied upon by the Examiner during the '166 Patent's prosecution.[4]

B. JPH10252512 ("Yuushiro")

Yuushiro is a Japanese patent application published September 22, 1998. Yuushiro is prior art under pre-AIA 35 U.S.C. §102(a) and §102(b). Yuushiro is accompanied by a certified translation and the original Japanese language document. Ex. 1006.[5].

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[4] Kobayashi was cited in a rejection of related U.S. Application No. 13/591,717 ("the '717 Application"). Ex. 1030, 54, 97-100. Rather than addressing the rejection, Patent Owner canceled the rejected claims. Ex. 1030, 97-100.

[5] Each of Exhibits 1006 – 1008 are accompanied by a certified translation and the original document in the same exhibit. 37 C.F.R. §42.63(b); 35 U.S.C. §312(a)(5);

C. DE19853799 ("Rubbert")

Rubbert is a German patent application published May 25, 2000. Rubbert is prior art under pre-AIA 35 U.S.C. §102(a) and §102(b). Rubbert is accompanied by a certified translation and the original German language document. Ex. 1007.

D. JP2002227697 ("Kinjiro")

Kinjiro is a Japanese patent application published August 14, 2002. Kinjiro is prior art under pre-AIA 35 U.S.C. §102(a) and §102(b). Kinjiro is accompanied by a certified translation and the original Japanese language document. Ex. 1008.

E. Bosch Automotive Handbook ("Bosch")

Bosch was published in 1993 and was publicly accessible prior to November 18, 2004. *See* Ex. 1037. Indeed, Dr. Mullins located Bosch at the Massachusetts Institute of Technology (MIT) Libraries and Purdue University Libraries and identified that MIT Libraries had added a receipt date of 1993, and Purdue University Libraries had added a receipt date of 1997. Ex. 1037, ¶¶44-50. Dr. Mullins confirmed the accessibility of Bosch at at least MIT and Purdue well before the priority date of the patent at issue. Ex. 1037, ¶¶51-60. Bosch is therefore

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Ninebot Tech. Co. v. Inventist, Inc., No. IPR2018-00134, Paper No. 11 at 10-11 (P.T.A.B. April 23, 2018).

prior art under pre-AIA 35 U.S.C. §102(a) and §102(b). Bosch is a well-known text on which a POSITA would have relied. Ex. 1003, ¶¶11, 280.

VI. LEVEL OF ORDINARY SKILL IN THE ART

A POSITA at the time of the invention would have had at least a bachelor's degree in engineering and at least five years of experience in the field of internal combustion engine design and controls. Ex. 1003, ¶10. Individuals with different education and additional experience could still be of ordinary skill in the art if that additional experience compensates for a deficit in their education stated above. *Id.* Additional education might substitute for some experience, and substantial experience might substitute for some educational background. *Id.*

VII. HOW THE CHALLENGED CLAIMS ARE UNPATENTABLE

At the time of the earliest possible priority date, the automobile industry was facing pressure to improve fuel economy and reduce emissions. Ex. 1032, 3; Ex. 1003, ¶31. By early 2000, engineers understood that regulations would soon require manufacturers to develop more environmentally friendly vehicles with more efficient engines. Ex. 1032, 3. Market forces had already led to the development of high specific output, low swept volume "downsized" engines. *Id*.

The '166 Patent outlines that high compression ratio operation and engine downsizing can improve energy efficiency of spark ignition engines. Ex. 1001, 1:35-41; Ex. 1003, ¶36. The '166 Patent discloses that engine downsizing is made possible by the use of substantial pressure boosting to obtain the same performance in a significantly smaller engine. Ex. 1001, 1:41-45; Ex. 1003, ¶36. The drawback of increased engine efficiency is the onset of engine knock, which "is the undesired detonation of fuel and can severely damage an engine." Ex. 1001, 1:48-51; Ex. 1003, ¶37.

Understanding that knock was the sole problem the '166 Patent sought to solve, a POSITA would have understood that there were a finite number of techniques to prevent knock in spark ignition engines—retarding ignition timing, and octane enhancement. Ex. 1003, ¶33.

To address knock, the '166 Patent relies on an antiknock agent (e.g., ethanol), which the '166 Patent states provides benefits that could not be achieved with gasoline or a gasoline/ethanol mixture. Ex. 1001, 4:14-17, 4:46-50. Patent Owner likewise advocated for such a system utilizing DI of an antiknock agent in the press. Ex. 1034. However, in an effort to assert its patents and by pursuing an aggressive continuation strategy, Patent Owner appears to have abandoned its ethanol-based innovation, opting instead for generic claims that Patent Owner purports cover a system that relies on PI and DI of the same fuel. Ex. 1022, ¶¶87-93.

As a result of claims that pivoted away from the specification, the '166 Patent claims the well-known concept of DI as a method for reducing knock.

Indeed, the ’166 Patent claims what Stokes (admitted prior art in the ’166 Patent) and others had already realized—DI eliminates knock in boosted “downsized” engines—nothing more. Ex. 1032. Engines relying on both PI and DI had been developed well in advance of the ’166 Patent. As evidenced by the prior art discussed below and the knowledge of a POSITA, the’166 Patent claims recite nothing more than use of the known technique of DI for knock-free operation in an engine that enabled both PI and DI. Ex. 1003, ¶33. The’166 Patent claims must be canceled.

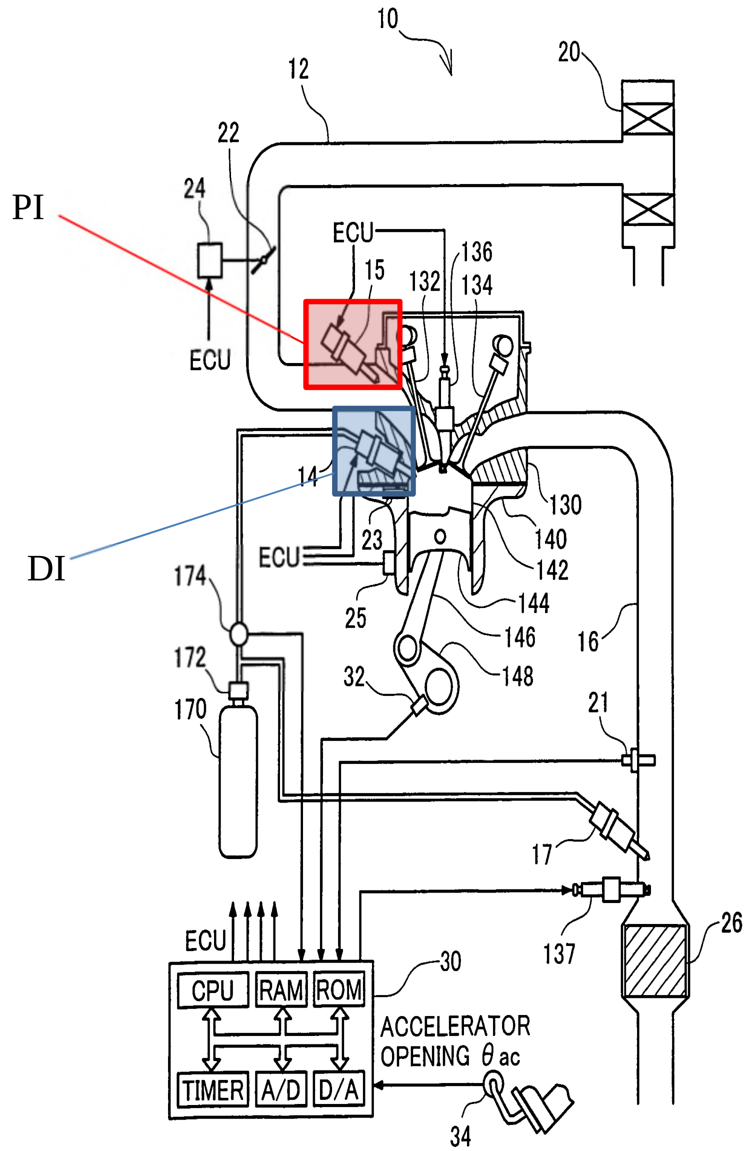
A. Ground 1: Claims 1-5, 7, 8, 10, 14-21 are Unpatentable Under 35 U.S.C. §103 over Kobayashi in view of Yuushiro

1. Overview of Ground 1

i. Overview of Kobayashi and Yuushiro

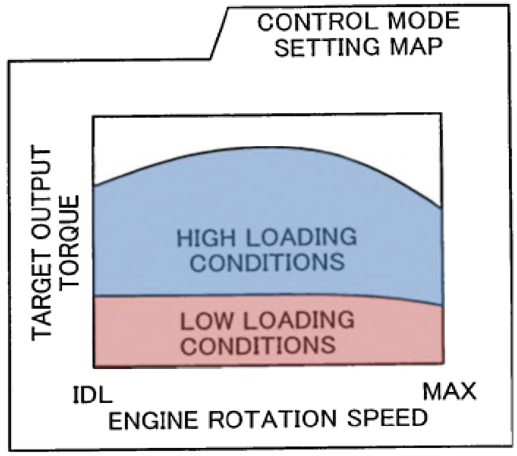
Kobayashi discloses an engine (Figure 1, below) that uses both PI and DI where the fuel quantity injected via the injection mechanisms is determined based on a fuel map. Ex. 1005, 9:44-47, 12:14-21; Ex. 1003, ¶158.

Fig.1



Based on output torque and other factors, Kobayashi's ECU is configured to access a fuel map. *See* Ex. 1005, 11:51-12:20, FIG. 4 (below).

Fig.4



Kobayashi uses PI fuel in both low and high loading conditions. Ex. 1005, 9:44-50; 12:7-12; Ex. 1003, ¶158. Kobayashi also uses a second, spark-ignited DI fuel in high loading conditions to ignite the PI fuel and avoid knocking. Ex. 1005, 15:65-16:27; Ex. 1003, ¶158. To the extent that it is argued that Kobayashi does not disclose an increase in the fuel provided by DI, it would be obvious to improve Kobayashi's fuel maps to include such features. Such fuel maps are shown at least by Yuushiro. Ex.1003, ¶¶158-166.

Yuushiro relies on an engine (Figure 1, below) with PI and DI. Ex. 1006, ¶¶[0025]-[0026].

[FIG. 1]

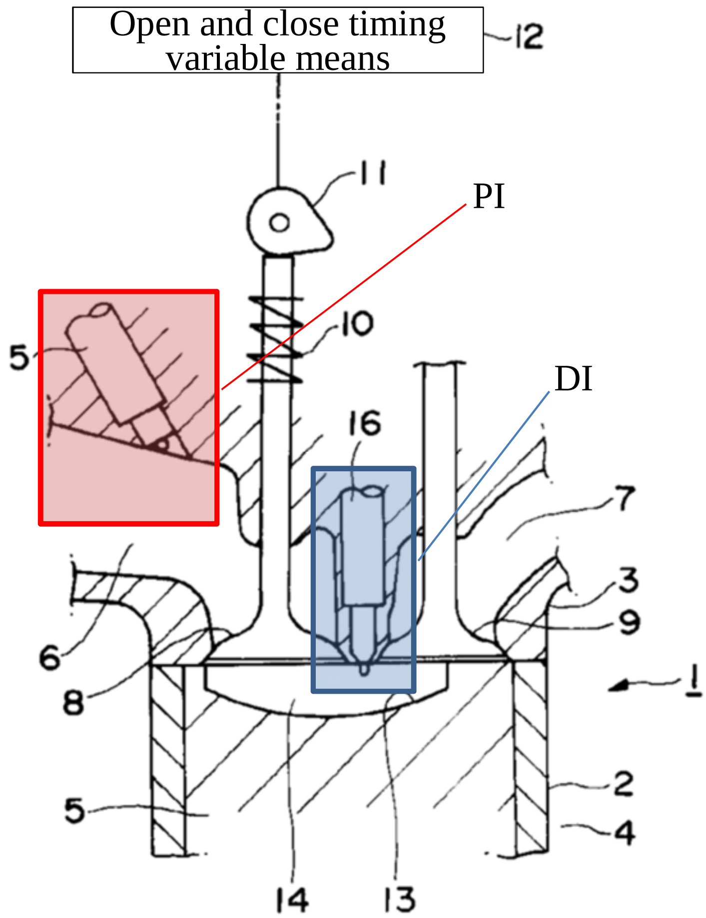
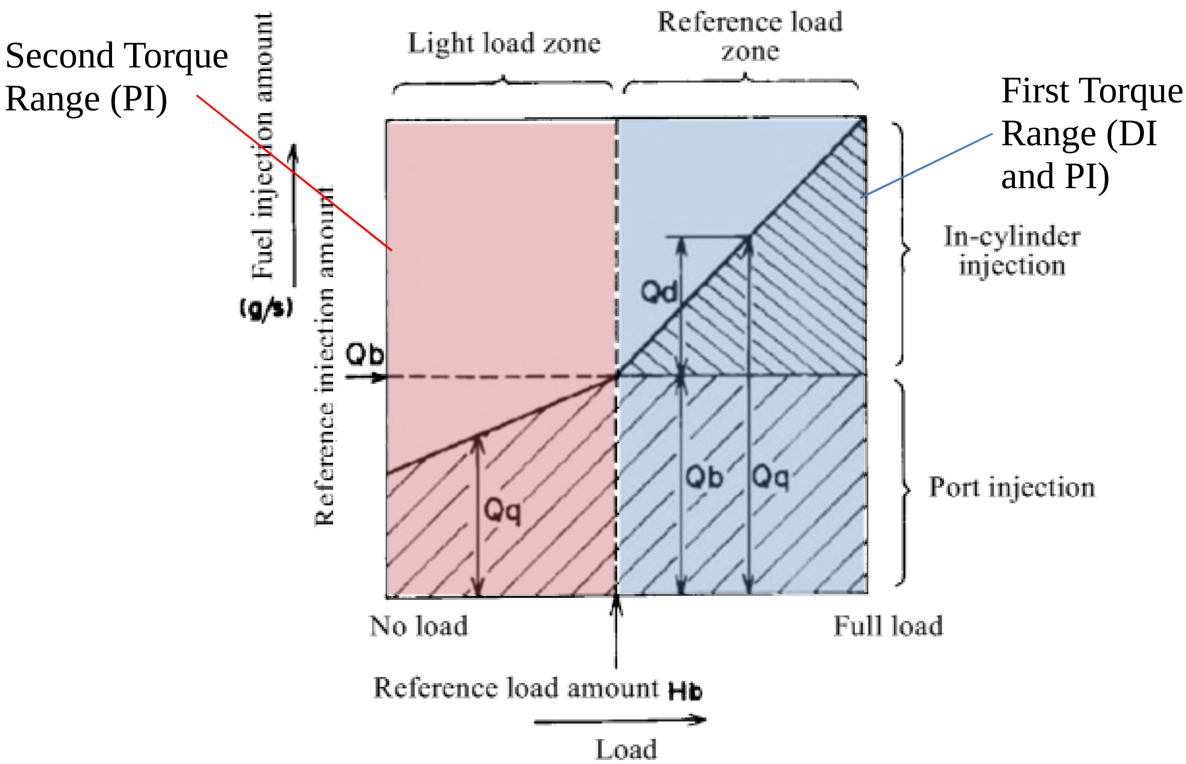


FIG. 3 is an example of Yuushiro's fuel map. *See* Ex. 1006, ¶[0039]. The fuel map illustrates Qq (the quantity of PI fuel) and Qd (the quantity of DI fuel). Qd is injected only when a load value exceeds the reference load value Hb (the determined maximum PI amount which does not cause knocking). Yuushiro illustrates in FIG. 3 a reference load zone, where both DI and PI are used, and a light load zone below, where only PI is used. Yuushiro further illustrates that the amount of DI fuel increases as load increases.

[FIG. 3]



ii. Motivation to Combine

A POSITA would have understood that Kobayashi discloses DI in high loading conditions. Ex. 1005, 9:58-65, 20:15-32; Ex. 1003, ¶159. A POSITA would have also understood that by relying on a lean air/fuel mixture, Kobayashi has a limit to its engine power output. Ex. 1003, ¶160. The POSITA would have looked to known techniques to increase engine power output, including increasing the ratio of fuel to air in the cylinder to be at or near a stoichiometric ratio. Ex. 1003, ¶¶160-61. Operating at or near a stoichiometric ratio would enable conventional three-way catalysts and support emissions reduction. Ex. 1025, 655; Ex. 1039, 3; Ex. 1003, ¶¶161-62.

A POSITA would have looked to Yuushiro, which discloses DI fuel making a substantive contribution to engine torque under high loading conditions (e.g., the reference load zone). Ex. 1003, ¶163. Yuushiro augments and improves the system of Kobayashi in that it supports a higher fuel to air ratio in the cylinder and allows for the amount of DI fuel to be increased as load is increased. *Id*. A POSITA would have been further motivated to look to Yuushiro when considering the aforementioned to increase power density or reduce emissions through catalysis given the similarities in design between the analogous systems of Kobayashi and Yuushiro. *Id*. Indeed, a POSITA would have understood that there had been demonstrated success in the use of DI fuel that made a substantive contribution to the engine torque and, thus, would have understood that there was a reasonable expectation of success in combining Kobayashi and Yuushiro. *Id.*, ¶¶163-66.

A POSITA would have been further motivated to look to Yuushiro given the similarities in design between Kobayashi and Yuushiro. Ex. 1003, ¶163. Kobayashi and Yuushiro address air/fuel mixture control with respect to a first, PI fuel and second, DI fuel. Ex. 1005, 9:47-50; Ex. 1006, ¶[0012]; Ex. 1003, ¶164. Both Kobayashi and Yuushiro control engine knocking with the addition of a second, DI fuel. Ex. 1005, 11:57-64; Ex. 1006, ¶¶[0017], [0039], [0055]; Ex. 1003, ¶165. While Kobayashi employs minimal fuel solely for knock management, Yuushiro improves Kobayashi, as it uses additional DI fuel that manages knock and provides for additional knock free torque production by the engine. Ex. 1003, ¶165.

A POSITA would have looked to Yuushiro and would have had a reasonable expectation of success in the combination even though Yuushiro discloses a compression ignition source.[6] Ex. 1003, ¶166. Whereas Yuushiro uses DI fuel that autoignites and ignites the PI fuel, Kobayashi uses a spark-ignited DI fuel that resists autoignition. *Id*. However, Kobayashi and Yuushiro both seek to create an ignition source for the same purpose. *Id.* A POSITA would have recognized that Yuushiro's DI strategy might be applied to extend the DI fuel quantity of Kobayashi. *Id.* A POSITA would have appreciated that this reliable ignition source could be established by employing a fuel suitable for spark ignition together with a spark or a fuel suitable for compression ignition at the temperatures in the cylinder. *Id*.

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[6] Krauja (U.S. Patent No. 4,721,081), directed to a compression ignition engine, was cited in the '033 Patent prosecution history. Ex. 1021, 89. Patent Owner did not contest the Examiner's citation of a compression ignition engine, confirming that references teaching compression ignition engines are relevant to the claims. *Id.*

2. *Claim 1: [1.Pre]: A fuel management system for a spark ignition engine which utilizes port fuel injection and also utilizes direct fuel injection;*

To the extent the preamble[7] of Claim 1 is limiting, Kobayashi discloses a spark ignition engine with a PI valve and a DI valve as shown in FIG. 1. Ex. 1005, FIG. 1, 9:44-50, 13:52-56; Ex. 1003, ¶¶167-171.

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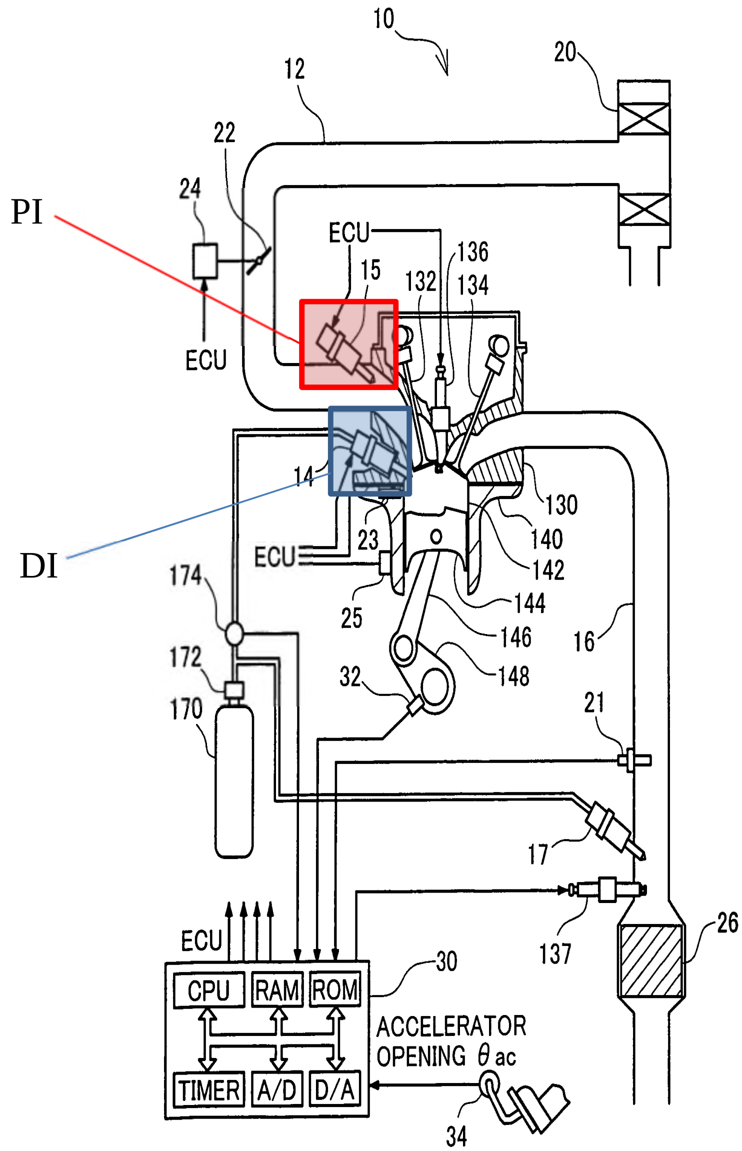
[7] This and other claims do not include a transitional phrase to indicate where the claim preamble ends and the claim body begins. The Federal Circuit has been clear that "poor claim drafting will not be an excuse for it to infuse confusion into its claim scope." *Acceleration Bay, LLC v. Activision Blizzard, Inc.*, 908 F.3d 765, 770.

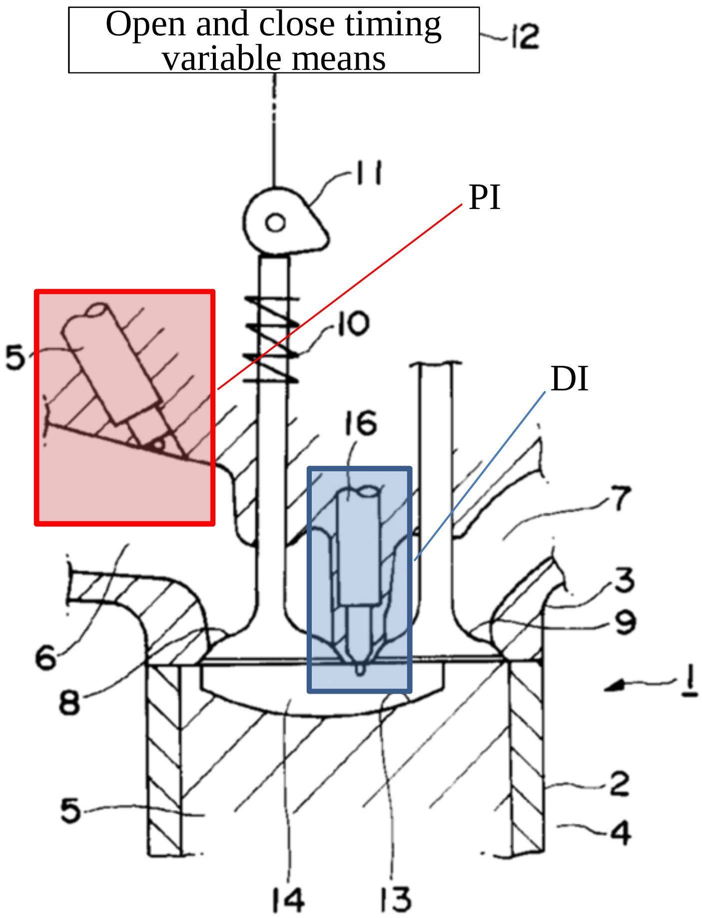
Fig.1



Kobayashi manages the fuel of an engine using an ECU. Ex. 1005, 10:16-17; Ex. 1003, ¶169. Specifically, Kobayashi's ECU uses fuel maps to determine the quantity of fuel to be injected. Ex. 1005, 12:14-21; Ex. 1003, ¶169.

As is shown in FIG. 1, Yuushiro relies on an engine with a PI valve and a DI valve. Ex. 1006, ¶¶[0025]-[0026]; Ex. 1003, ¶175.

[FIG. 1]

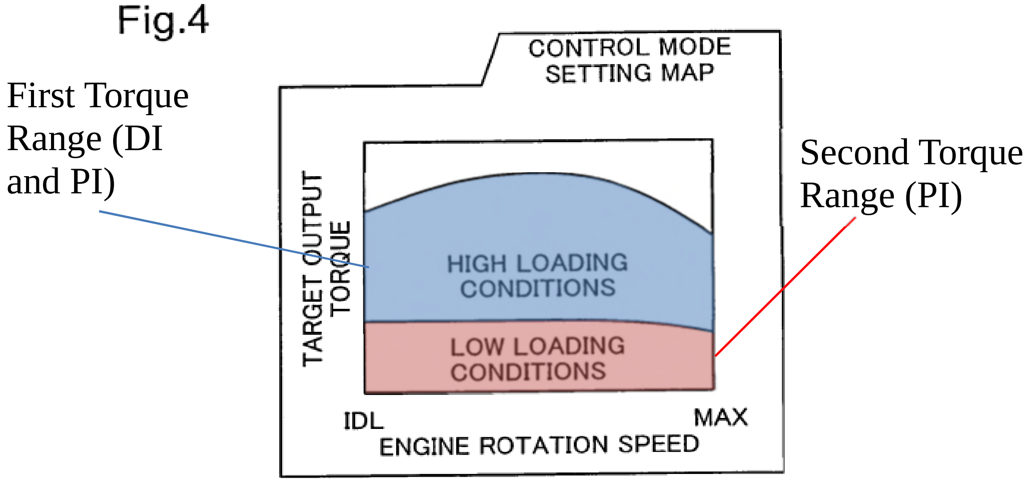


3. *Claim 1: [1.A]: and where there is a first torque range where direct injection and port injection are both used at the same value of torque throughout the first torque range*

Petitioner interprets Limitation 1.A to mean DI and PI are both used to fuel the engine at any value of torque in the first torque range. Ex. 1003, ¶176; Ex. 1036, 1.

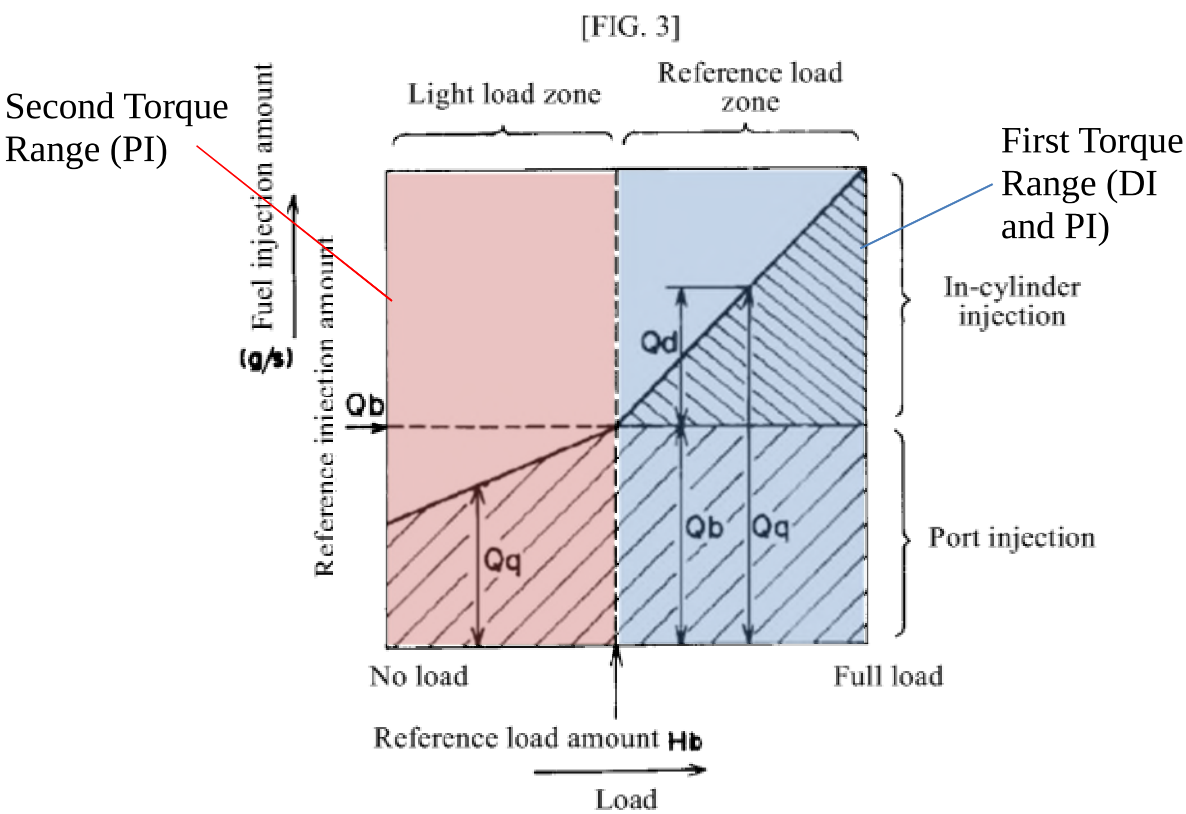
In Kobayashi, the ECU calculates output torque based on a load demand. Ex. 1005, 11:32-46; Ex. 1003, ¶177. The ECU then uses the calculated output torque and maps that torque to a fuel map, as in FIG. 4 below. Ex. 1005, 11:51-12:13; Ex. 1003, ¶177. The operation range where PI alone is used is the range where there is not a problem with knock, identified below as "low loading conditions." Beyond that range, in the "high loading conditions," both PI and DI injectors are employed (first torque range). Ex. 1005, 9:44-50; 11:53-12:2; Ex. 1003, ¶¶177-79.

Fig.4



Yuushiro discloses what is referred to as "reference injection/reference load" fuel amount, which is the maximum amount of fuel that can be injected via PI alone without causing knock. Ex. 1006, ¶¶[0012], [0038]; Ex. 1003, ¶181. In a load region where load is less than or equal to the reference load (e.g., light load zone), Yuushiro relies on PI alone to supply the necessary fuel amount. Ex. 1006, ¶¶[0012], [0039]; Ex. 1003, ¶181. In a load region where load is greater than the reference load (e.g., reference load zone), Yuushiro relies on both PI and DI at any value of torque to provide fuel. Ex. 1006, ¶[0039]; Ex. 1003, ¶181.

Yuushiro illustrates in FIG. 3 that as load increases beyond the reference load value, the engine uses both DI and PI. Because of the Patent Owner's admission that load correlates to torque, the reference load zone, where both DI and PI are used, correlates to a "first torque range" and the light load zone below, where only PI is used, correlates to the "second torque range."

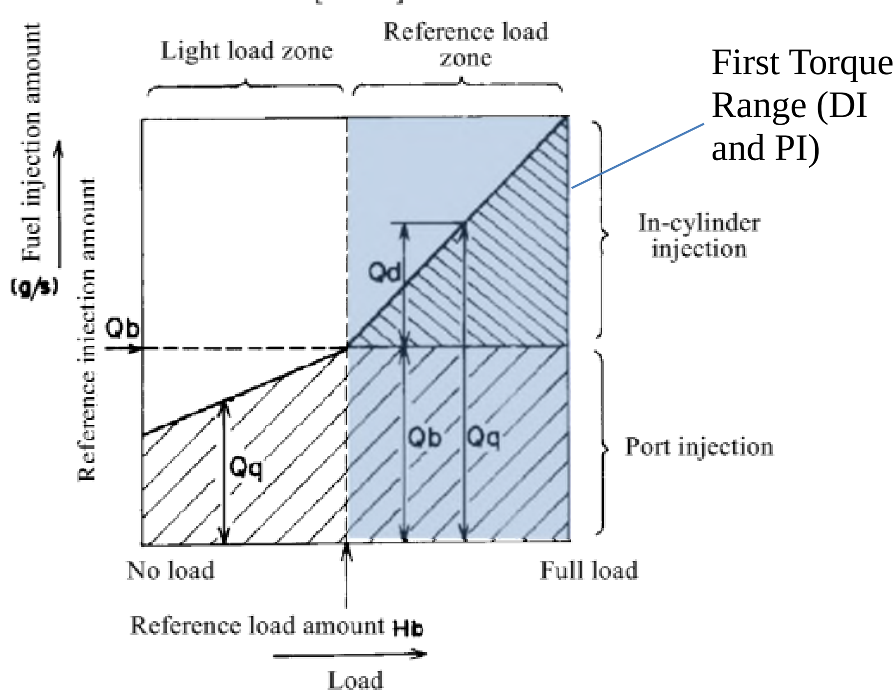


> **4.** ***Claim 1: [1.B]: and where in at least part of the first torque range as torque is increased the amount of fuel that is directly injected is changed so as to obtain knock-free operation and the amount of directly injected fuel used to provide knock-free operation is minimized.***

Kobayashi discloses using sufficient fuel to prevent knock. Ex. 1005, 9:58-65, 11:57-64, 12:8-13; Ex. 1003, ¶182. Kobayashi also teaches minimizing the use of DI fuel based on its explicit reliance on a small volume of fuel to ignite the PI fuel. Ex. 1005, 20:23-25, 25:22, 25:58; Ex. 1003, ¶183. Kobayashi confirms that the DI fuel tank has a small required volume. Ex. 1005, 20:29-32; Ex. 1003, ¶183. By using PI alone in the low load conditions, *e.g.*, at zero torque, Kobayashi discloses minimizing the amount of DI fuel. Ex. 1005, 9:44-50; 11:53-58; Ex. 1003, ¶¶183-84, 204.

As stated above, a POSITA would augment Kobayashi with the teachings of Yuushiro. Yuushiro illustrates in FIG. 3 that as load increases in the reference load zone, the quantity of DI fuel (Qd) increases. Ex. 1003, ¶¶185-86.

[FIG. 3]



Yuushiro also discloses minimizing DI fuel use. Ex. 1003, ¶187. The amount of DI fuel in the light load zone is necessarily minimized, as no fuel is directly injected. Ex. 1006, ¶¶[0012], [0039]; Ex. 1003, ¶187. In the reference load zone, the minimum amount of fuel is directly injected because Yuushiro teaches directly injecting only the amount of fuel necessary to obtain the required power output while maintaining knock free operation at the desired torque, e.g., according to Qd = Qq-Qb, where Qd is the DI fuel injected, Qq is the total fuel injected, and Qb is the reference load injection. Ex. 1006, ¶[0039]; Ex. 1003, ¶187; *see also* Ex. 1036, 3.

5. *Claim 2: The fuel management system of claim 1 where as torque is increased the fraction of fuel that is directly injected is increased to the value that prevents knock.*

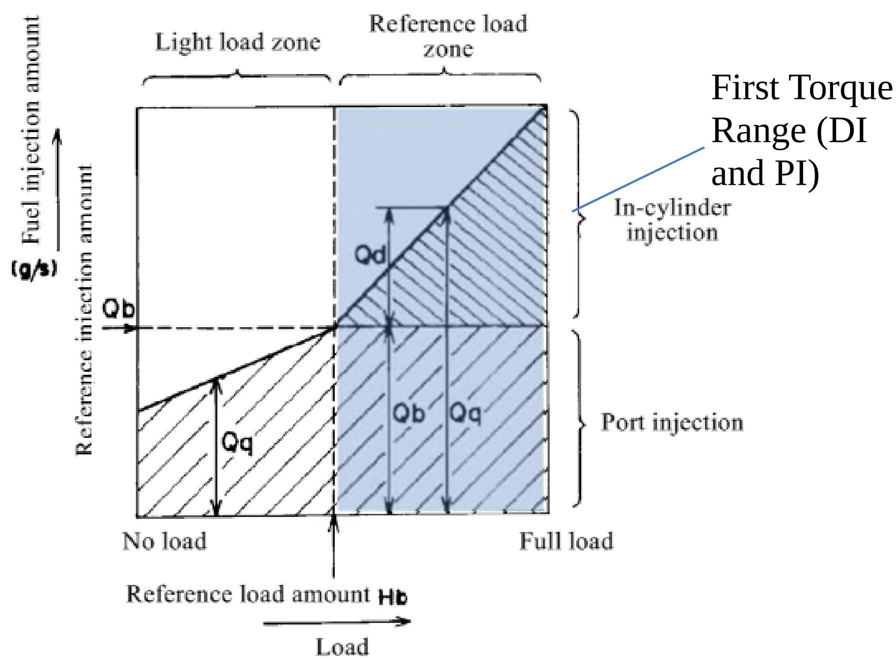
Kobayashi and Yuushiro disclose increasing the fraction of DI fuel to the value that prevents knock when torque increases. *See supra* §VII(A)(4); Ex. 1006, ¶[0039], FIG. 3 (illustrating as load increases in the reference load zone, the quantity of DI fuel (Qd) increases); Ex. 1003, ¶¶188-190.

6. *Claim 3: The fuel management system of claim 1 where active control using a knock detector is used to change the amount of fuel that is directly injected as torque is increased.*

Kobayashi's ECU controls engine operations. Ex. 1005, 10:16-17; Ex. 1003, ¶191. An ECU function disclosed by Kobayashi is to detect knocking via a knock sensor. Ex. 1005, 10:34-48; Ex. 1003, ¶191. In response to knock detection, Kobayashi uses DI to reduce knock. Ex. 1005, 9:58-65, 11:57-64; Ex. 1003, ¶191.

As described above, Yuushiro augments Kobayashi and discloses that the use of DI would change or increase as Yuushiro discloses the amount of DI fuel above a reference load to prevent knock. Ex. 1003, ¶192. FIG. 3 of Yuushiro explicitly demonstrates increasing the quantity of DI fuel as torque increases to prevent knock. *Id*.

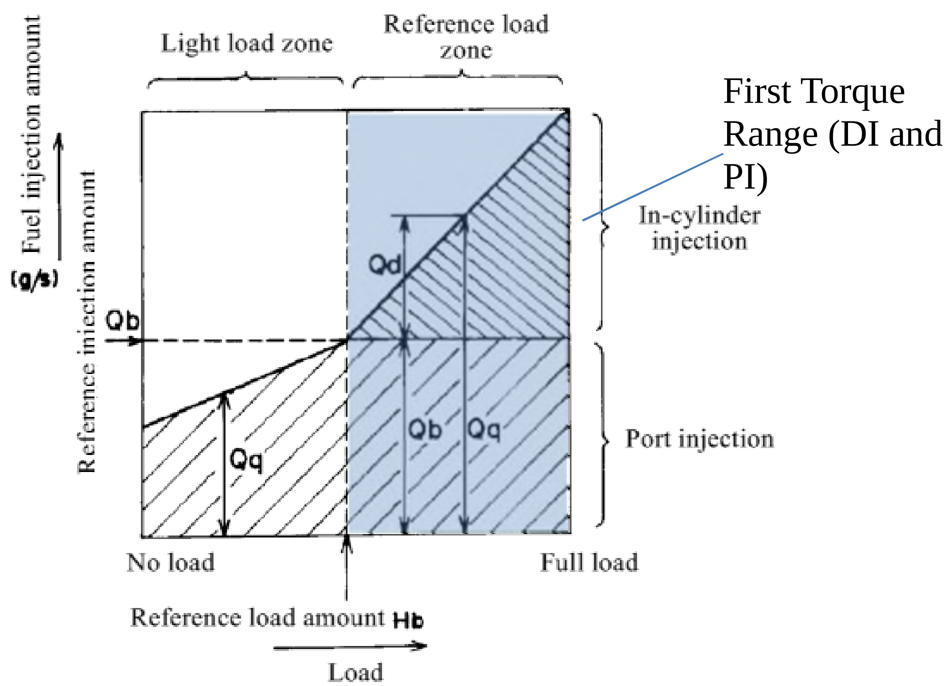
[FIG. 3]



7. ***Claim 4: The fuel management system of claim 1 or 2 where open loop control using a lookup table is also used to change the amount of fuel that is directly injected as torque is increased.***

Kobayashi discloses open loop control in at least FIG. 3. Ex. 1005, 11:29-31; Ex. 1003, ¶196. Kobayashi determines the amount of DI fuel used via a lookup table including the target output torque and engine rotation speed. Ex. 1005, 13:3-13; Ex. 1003, ¶197. Yuushiro discloses open loop control in its fuel map that illustrates changing or increasing the amount of DI fuel above a reference load to prevent knock. FIG. 3. Ex. 1006, FIG. 3; Ex. 1003, ¶198. A POSITA would have understood that a fuel map, like a lookup table, is an example of open loop control, as both a fuel map and a lookup table are a series of data entries relating torque or load and a quantity of fuel. Ex. 1003, ¶195.

[FIG. 3]



8. *Claim 5: The fuel management system of claim 4 where a predetermined correlation between knock resistance and fraction of fuel provided by direct injection is employed.*

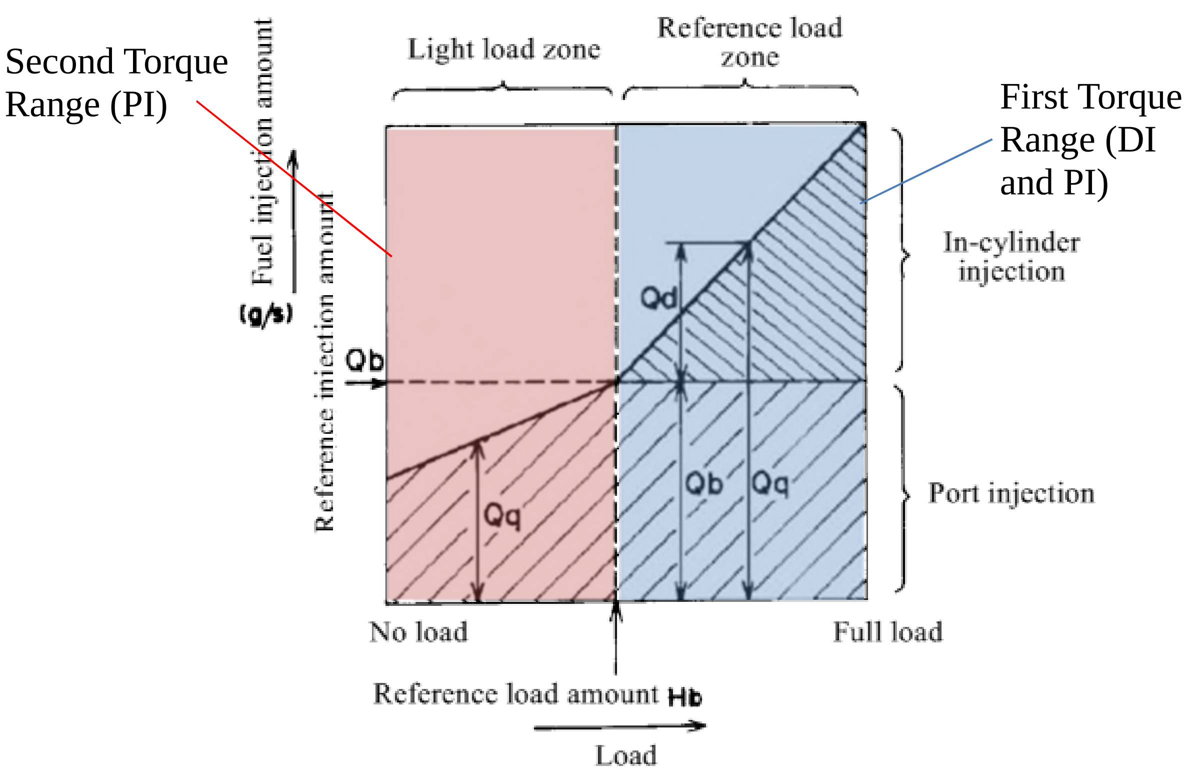
Kobayashi and Yuushiro each disclose fuel maps and, therefore, open loop control. Ex. 1005, 13:11-13; Ex. 1006, ¶[0038]; Ex. 1003, ¶¶200-203; *see supra* §VII(A)(7). Indeed, each of Kobayashi and Yuushiro disclose the purpose of their fuel maps is to use DI to eliminate knock. Ex. 1005, 11:51-12:13; Ex. 1006,

¶[0039]. Further, a POSITA would understand that open loop control relies on a predetermined correlation between knock resistance and the amount of DI fuel used. Ex. 1003, ¶¶200-203.

9. Claim 7: The fuel management system of claim 1 where only port fuel injection is used in a second range of torque.

Kobayashi and Yuushiro each disclose using PI alone in a particular load range. *See supra* §VII(A)(3); Ex. 1005, 9:44-50; 11:53-12:2; Ex. 1006, ¶¶[0012], [0039], FIG. 3 (light load zone); Ex. 1003, ¶¶204-207.

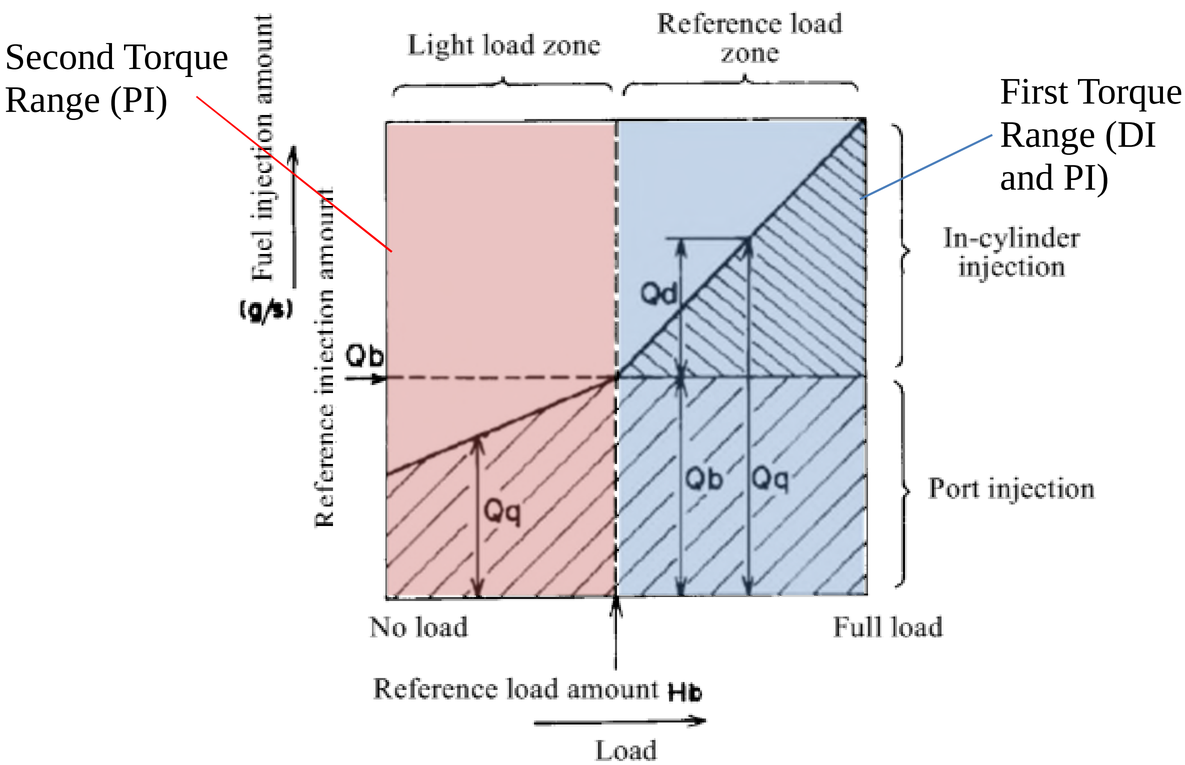
[FIG. 3]



10. *Claim 8: The fuel management system of claim 7 where as the torque increases beyond the highest value of torque in the second range of torque, the engine operates in the first range of torque.*

Kobayashi and Yuushiro both disclose transitioning from PI only at some loads to a mixture of PI and DI at higher loads. *See supra* §VII(A)(3); Ex. 1005, 9:44-50; 11:53-12:2; Ex. 1006, ¶[0039], FIG. 3 (transitioning from light load zone to reference load zone at reference load amount Hb); Ex. 1003, ¶¶208-211.

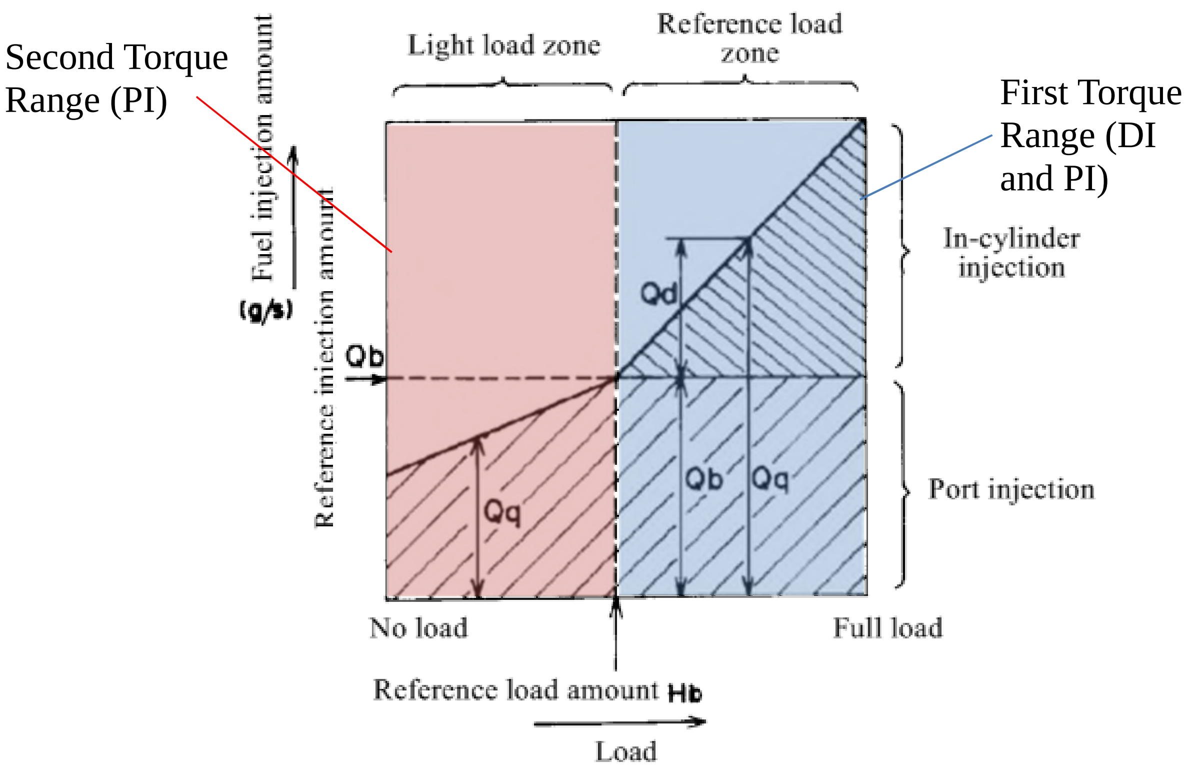
[FIG. 3]



11. Claim 10: The fuel management system of claim 7 where the highest torque in the second torque range is the highest torque at which knock-free operation can be obtained with port fuel injection alone.

Kobayashi and Yuushiro each disclose using PI alone in a particular load range. *See supra* §VII(A)(3); Ex. 1005, 9:44-50; 11:53-12:2; Ex. 1006, ¶¶[0012], [0039]; FIG. 3 (highest torque in the light load zone is Hb); Ex. 1003, ¶¶212-216.

[FIG. 3]



12. Claim 14: The fuel management system of claim 1 where the amount of directly injected fuel is minimized throughout the first torque range.

As is discussed with respect to Claim 1, Kobayashi and Yuushiro disclose minimizing the amount of DI fuel throughout the first torque range. *See supra*

§VII(A)(4); Ex. 1005, 20:23-32, 25:22, 25:58; Ex. 1006, ¶[0039]; Ex. 1003, ¶¶217-221; *see also* Ex. 1036, 27.

13. Claim 15: The fuel management system of claim 1 where the amount of directly injected fuel is minimized from zero torque to the highest torque in the first torque range.

As is discussed with respect to Claim 1, Kobayashi and Yuushiro disclose minimizing the amount of DI fuel throughout the first and second torque ranges, including at zero torque (e.g., by not injecting any fuel via the direct injector). *See supra* §VII(A)(4); Ex. 1005, 9:44-50; 11:53-58, 20:23-32, 25:22, 25:58; Ex. 1006, ¶¶[0012], [0039]; Ex. 1003, ¶¶222-227; *see also* Ex. 1036, 30.

14. Claim 16: The fuel management system of claim 1 where there is third torque range where the highest torque is the highest torque in the first torque range of the operation and where within the third torque range as torque is increased the fraction of fuel provided by direct injection is changed to the value needed to prevent knock.

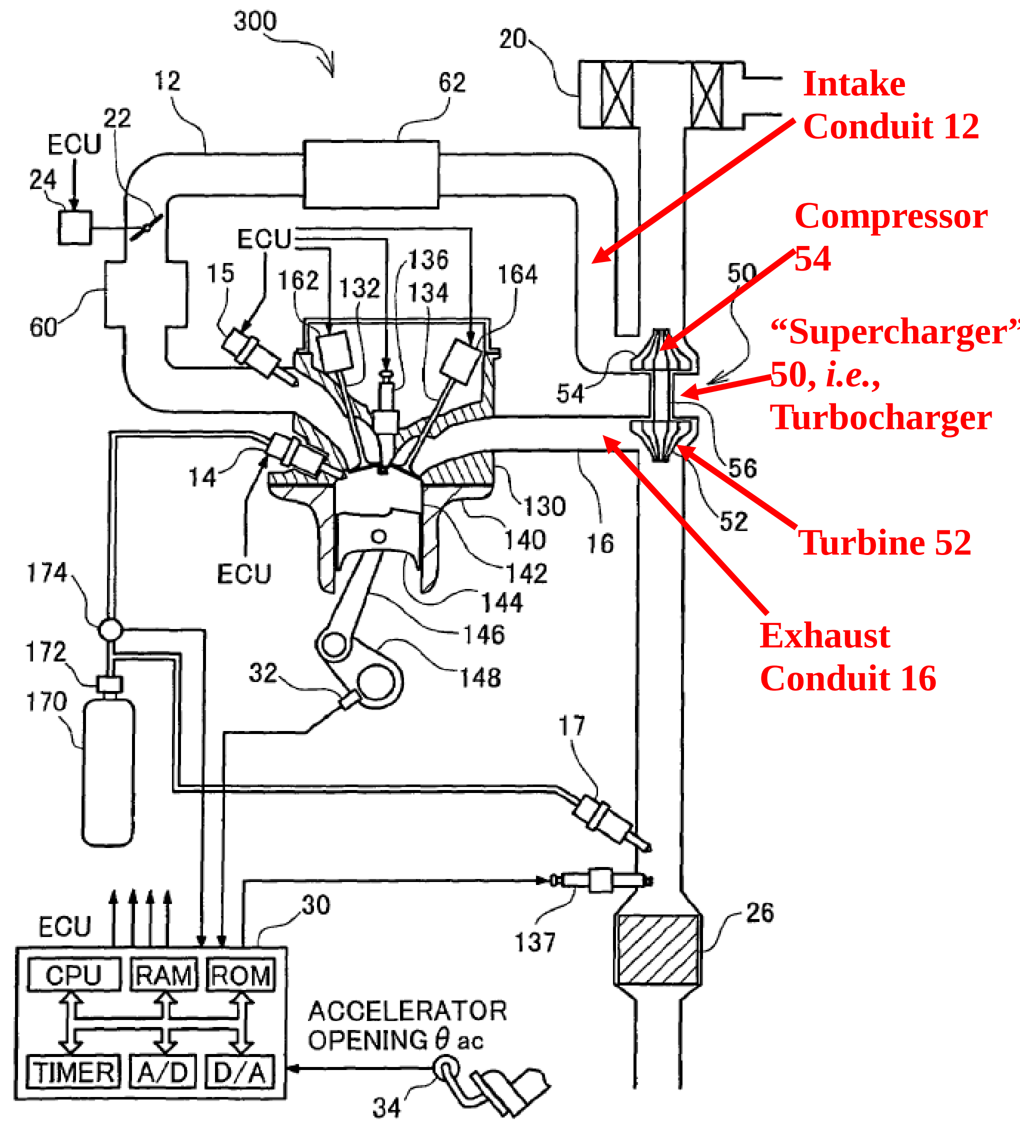
The third torque range can be interpreted to be the same as, or at least to include a portion of, the first torque range, as the third torque range and the first torque range have a common highest torque value. Ex. 1003, ¶228. Kobayashi and Yuushiro have been shown above to disclose that the fraction of fuel provided by DI is changed to the value needed to prevent knock in the first torque range and, thus, for the same reasons disclose Claim 16. *See supra* §VII(A)(4); Ex. 1005, 9:58-65, 11:57-64, 12:8-13; Ex. 1006, FIG. 3; Ex. 1003, ¶¶228-232.

15. Claim 17: The fuel management system of claim 9 or 16 where the engine is turbocharged.

Claim 17 is challenged only on the basis of its dependency from Claim 16. Ex. 1003, ¶233; *see Amerigen Pharms. Ltd. v. Shire LLC*, No. IPR2015-02009, Paper 38 at 4 (P.T.A.B. March 31, 2017).

Kobayashi discloses a turbocharger. Ex. 1003, ¶¶234-235. Kobayashi discloses an embodiment including a supercharger disposed in the exhaust conduit. Ex. 1005, 26:21-37. Ex. 1003, ¶234. A POSITA would understand that the structure of the "supercharger," which includes a turbine disposed in the exhaust conduit and a compressor disposed in the intake conduit, as shown in FIG. 18 below, is a conventional arrangement for a turbocharger. Ex. 1003, ¶235.

Fig.18



16. Claim 18: The fuel management system of claim 16 where the amount of direct injection is minimized.

As is discussed with respect to Claim 1, Kobayashi and Yuushiro disclose minimizing the amount of DI fuel injected. *See supra* §VII(A)(4); Ex. 1005, 9:44-50; 11:53-58, 20:23-32, 25:22, 25:58; Ex. 1006, ¶¶[0012], [0039]; Ex. 1003, ¶¶236-240; *see also* Ex. 1036, 35.

17. Claim 19 [19.Pre]: A fuel management system for a turbocharged spark ignition engine which utilizes port fuel injection and also utilizes direct fuel injection;

Claim 19 is substantially similar to Claims 1, 2, 7, 8, and 17 and is likewise disclosed. Specifically, Claim 19.Pre is substantially the same as 1.Pre. *See supra* §§VII(A)(2), (15); Ex. 1003, ¶¶241-250. Claim 19.Pre differs from 1.Pre in that it includes a "turbocharged" engine. A "turbocharged" engine is disclosed by the combination shown with respect to Claim 17. *Id.*

18. Claim 19 [19.A]: and where there is a first range of torque throughout which direct injection and port injection are used at the same value of torque;

Claim 19.A is substantially similar to 1.A and is likewise disclosed. *See supra* §VII(A)(3); Ex. 1003, ¶¶251-256.

19. Claim 19 [19.B]: and wherein as torque is increased the fraction of fuel that is directly injected is increased to a value that prevents knock;

Claim 19.B is substantially similar to 1.B and 2 and is likewise disclosed. *See supra* §VII(A)(4), (5); Ex. 1003, ¶¶257-258.

20. Claim 19 [19.C]: and where there is a second range of torque where only port fuel injection is used;

Claim 19.C is substantially similar to Claim 7 and is likewise disclosed. *See supra* §VII(A)(3), (9); Ex. 1003, ¶¶259-262.

21. Claim 19 [19.D]: and where when torque exceeds the highest torque in the second range of torque the engine operates in the first range of torque.

Claim 19.D is substantially similar to Claim 8 and is likewise disclosed. *See supra* §VII(A)(3), (10); Ex. 1003, ¶¶263-266.

22. Claim 20: The fuel management system of claim 19 where the second torque range starts at zero torque.

Kobayashi and Yuushiro disclose a second torque range starting at zero torque in which PI alone is used. *See supra* §VII(A)(4); Ex. 1005, 9:44-50; 11:53-12:2; Ex. 1006, ¶¶[0012], [0039], FIG.. 3 (illustrating light load zone starting at no load); Ex. 1003, ¶¶267-270.

23. Claim 21: The fuel management system of claim 19 or 20 where the highest value of torque in the second region of torque is the highest value of torque at which direct injection is not needed to prevent knock.

Kobayashi and Yuushiro both disclose transitioning from PI only at some loads to a mixture of PI and DI at higher loads. *See supra* §VII(A)(4); Ex. 1005, 9:44-50; 11:53-12:2; Ex. 1006, ¶[0039]; Ex. 1003, ¶¶271-276.

B. Ground 2: Claims 1-5, 7, 8, 10-24, 26-30 are Unpatentable Under 35 U.S.C. §103 over Rubbert in view of Yuushiro and Bosch

1. Overview of Ground 2

i. Overview of Rubbert, Yuushiro, and Bosch

Rubbert discloses a dual injection, load dependent, spark ignited engine. Ex. 1003, ¶283. Rubbert teaches a larger quantity of PI fuel at low load and a larger quantity of DI fuel at high load. *Id*. Rubbert is silent as to the actual quantity of DI fuel, stating only that the injection quantities are based on load. Ex. 1007, 1:49-2:8; Ex. 1003, ¶283. Many details required to implement Rubbert's invention would be known by a POSITA (e.g., based on defined fuel maps). Ex. 1003, ¶283. Indeed, a POSITA would have understood that these controls would be defined by fuel maps. *Id*. Such fuel maps are shown at least by Yuushiro. *See supra* §VII(A)(1).

Moreover, it may be argued that the combination of Rubbert and Yuushiro does not teach or suggest one or more of spark retard, turbocharging, or closed loop control. Spark retard, turbocharging, and closed loop control were well-known in fuel management systems, which is illustrated by Bosch. Ex. 1031, 360, 372-74, 441, 464-65; Ex. 1003, ¶291. Bosch discloses the use of turbochargers. Ex. 1031, 372-74. Bosch also discloses the use of a knock sensor to adjust engine variables to eliminate knock, including but not limited to spark retard. Ex. 1031, 464-465. Bosch discloses that it was "customary" as of 1993 to use spark retard to eliminate combustion knock. Ex. 1031, 360.

ii. Motivation to Combine

Because Rubbert states its fuel injection strategy is based on load, a POSITA would have been motivated to select a known fuel map that provided specific quantities of PI and DI fuel based on load. Ex. 1003, ¶284. For at least this reason, a POSITA would have implemented Yuushiro's fuel map (Yuushiro is described with respect to §VII.A *supra*) in Rubbert. Ex. 1006, ¶[0039]; Ex. 1003, ¶284.

Yuushiro echoes the teachings of Rubbert. Ex. 1003, ¶286. A POSITA would have understood that Yuushiro's fuel map is designed to rely on an increasing amount of DI to prevent knock ***as engine load increases***. *Id*. Such a map not only allows for the advantages of DI with respect to cylinder filling, but also enables the knock limit to be fully utilized. *Id*., ¶¶286-287. Moreover, a POSITA would have had a reasonable expectation of success of achieving the predictable result of an engine that reduces knock based on both PI and DI based on a known fuel map. *Id*., ¶287.

A POSITA would have looked to Yuushiro even though Yuushiro discloses a compression ignition source. Ex. 1003, ¶288. Whereas Yuushiro discloses DI fuel that autoignites and in turn ignites the PI fuel, Rubbert uses a spark-ignited DI fuel that resists autoignition. *Id*. However, Rubbert and Yuushiro both seek to create an ignition source for the same purpose. *Id*. A POSITA would have recognized that Yuushiro's DI strategy could be applied to extend the DI fuel quantity of Rubbert. *Id*. A POSITA would have appreciated that this reliable ignition source could be established by employing a fuel suitable for spark ignition together with a spark or a fuel suitable for compression ignition at temperatures present in the cylinder. *Id*. A POSITA would consider the implementation details of Yuushiro to be standard and would have understood they could likewise be implemented in Rubbert's engine. *Id*.

The combination of Rubbert and Yuushiro is silent as to reliance on spark retard, turbocharging, and closed loop control. Ex. 1003, ¶¶289-91. A POSITA would have been motivated to identify those additional implementation details and would have understood these details were well known in the art at the time. *Id.* For example, a POSITA would have been motivated to reduce the displacement of the engine while maintaining desired power. Ex. 1001, 1:41-48 (citing Ex. 1032); Ex. 1003, ¶¶36, 290-91. Indeed, the employment of spark retard would be beneficial to reduce the amount of fuel that is directly injected. Ex. 1003, ¶291. As such, a POSITA would have been motivated to reduce knock using well-understood methods, including spark retard, turbocharging, and through the use of a knock sensor. *Id*.

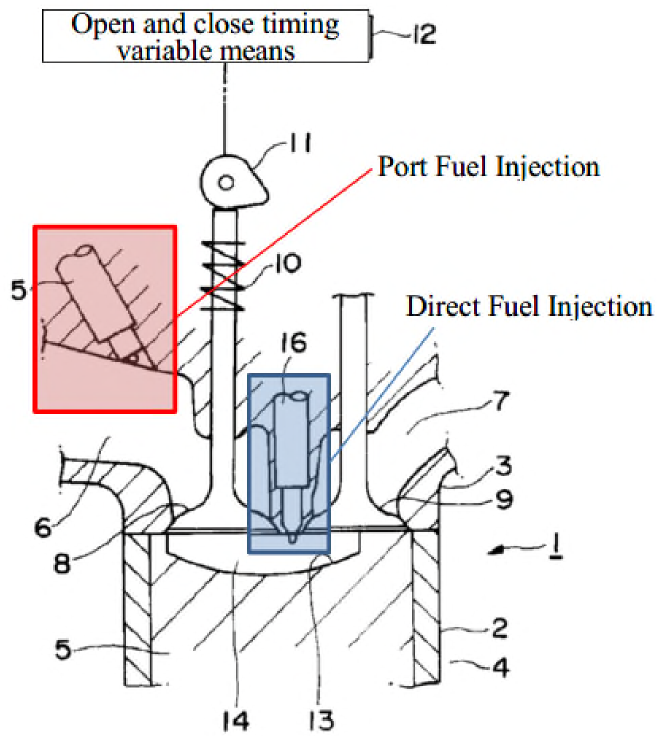
Bosch, a widely relied-upon reference, discloses turbochargers, the mechanics of spark ignition and knock, along with explanations as to why a POSITA would rely on spark retard to improve engine operation. Ex. 1031, 372-74; Ex. 1003, ¶¶280-82, 291. Bosch also confirms that turbochargers were a major focus (along with DI) at the time of Rubbert and Yuushiro. Ex. 1031, 372-74. Bosch further discloses the use of a knock sensor to adjust engine variables to eliminate knock, including but not limited to spark retard. Ex. 1031, 464-465; Ex.

1003, ¶291. A POSITA would have understood that the knock sensor could have been applied to the management of other engine variables that influence knock, including DI quantity per Rubbert and Yuushiro. Ex. 1003, ¶291. As such, given the ubiquitous nature of spark retard, turbochargers, and closed loop control in spark ignition engines, a POSITA would have had a reasonable expectation of success and would have expected a predicable result, *i.e.*, the reduction in knock. *Id*.

2. Claim 1: [1.Pre]: A fuel management system for a spark ignition engine which utilizes port fuel injection and also utilizes direct fuel injection;

To the extent the preamble of Claim 1 is limiting, Rubbert discloses a spark ignited engine relying on a "combination of a port injection with a direct injection through respective, load-dependent controlled / regulated partial injection quantities." Ex. 1007, 1:3-5, 31-34; Ex. 1003, ¶293. As is described previously herein and below, Yuushiro also discloses the management of fuel in an engine with both PI and DI. Ex. 1003, ¶294; *see supra* §VII(A)(2).

[FIG. 1]



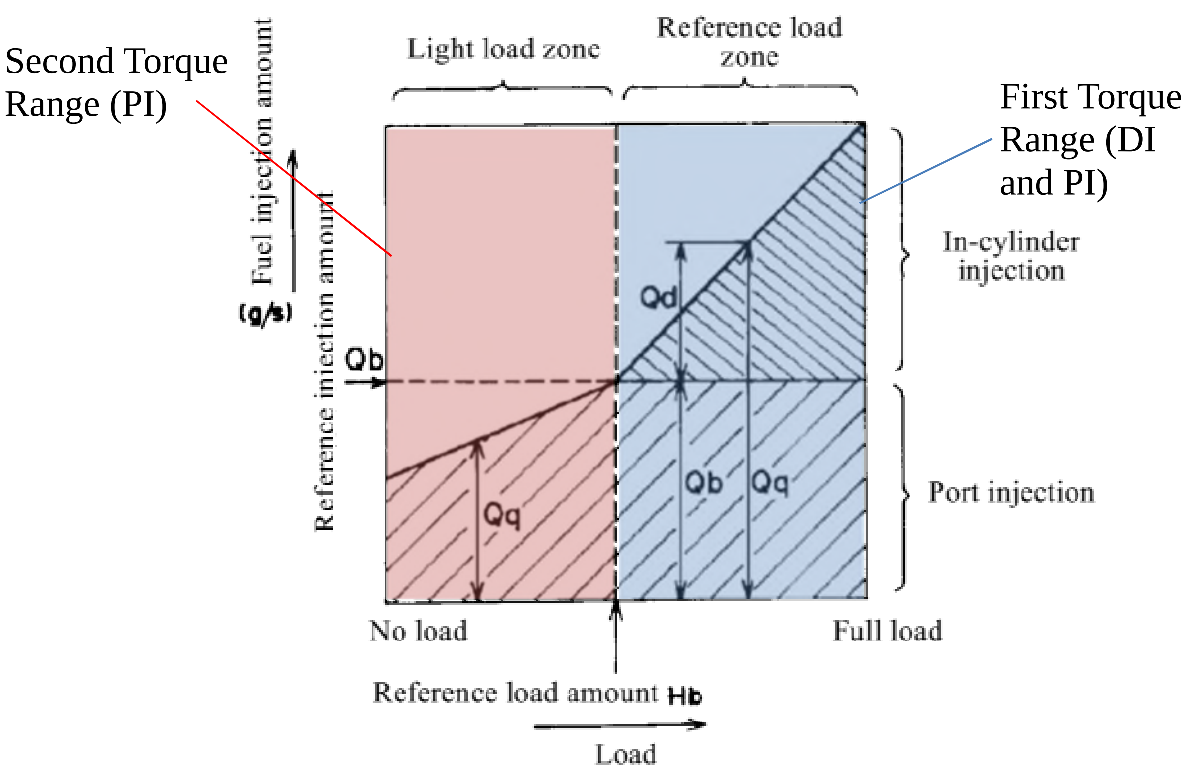
3. *Claim 1: [1.A]: and where there is a first torque range where direct injection and port injection are both used at the same value of torque throughout the first torque range*

Petitioner interprets Limitation 1.A to mean DI and PI are both used to fuel the engine at any value of torque in the first torque range. Ex. 1003, ¶297; *see supra* §VII(A)(3).

Rubbert discloses that the combination of PI and DI is load-dependent with regulated partial injection quantities to form an air/fuel mixture. Ex. 1007, 1:31-34; Ex. 1003, ¶298. Rubbert discloses that under idle conditions and part (low) load range, the larger proportion of fuel in the mixture is injected via PI whereas in full load ranges, DI is used. *See* Ex. 1007, 1:49-2:8; Ex. 1003, ¶299.

Yuushiro discloses and provides additional implementation details with respect to a first torque range where both DI and PI are used. Ex. 1003, ¶300. Yuushiro relies on a calculated load to determine whether to use PI alone or the combination of PI and DI. Ex. 1006, ¶[0039]; Ex. 1003, ¶300. Yuushiro illustrates in FIG. 3 that as load increases beyond the reference load value, the engine uses both DI and PI. Because of the Patent Owner's admission that load correlates to torque, the reference load zone, where both DI and PI are used, correlates to a "first torque range" and the light load zone below, where only PI is used, correlates to the "second torque range." *See supra* §VII(A)(3); Ex. 1003, ¶301.

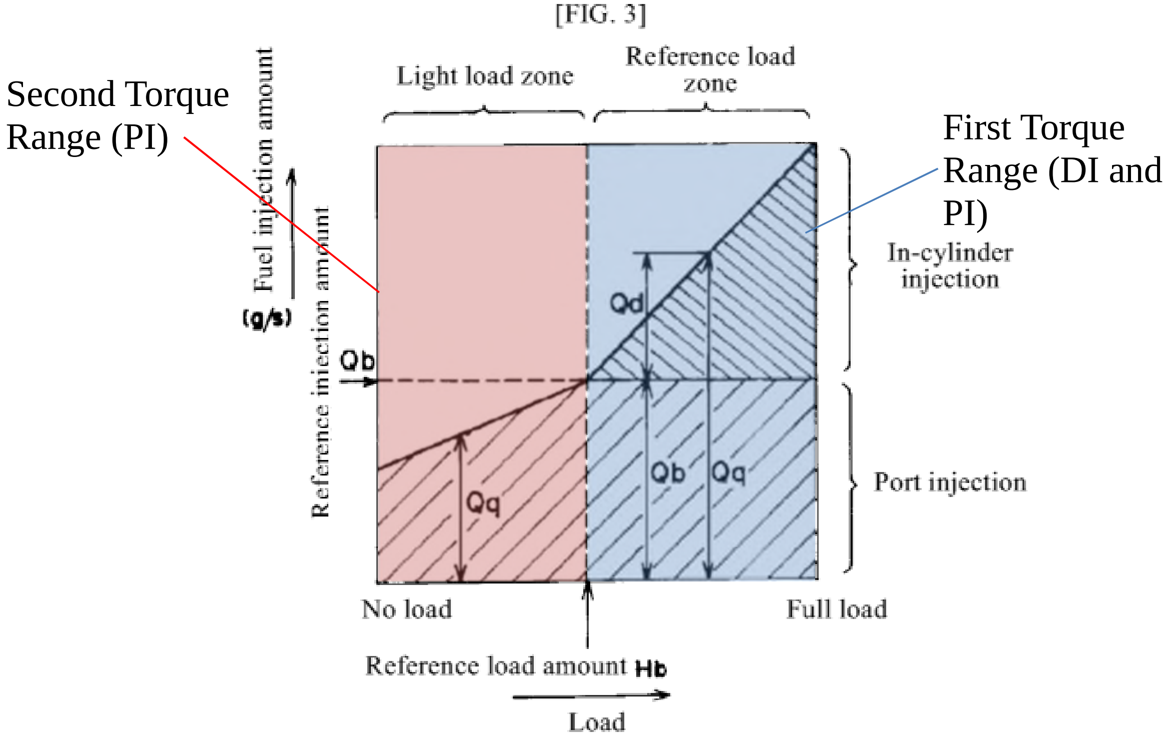
[FIG. 3]



4. Claim 1: [1.B]: and where in at least part of the first torque range as torque is increased the amount of fuel that is directly injected is changed so as to obtain knock-free operation and the amount of directly injected fuel used to provide knock-free operation is minimized.

While Rubbert teaches a changing ratio between the amount of DI fuel and PI fuel in high load conditions, a POSITA would rely on the disclosure of Yuushiro that demonstrates that as load increases in the reference load zone, the quantity of DI fuel likewise increases. Ex. 1003, ¶303. Yuushiro discloses that the amount of DI fuel is changed as load increases and that the amount of directly injected fuel used to provide knock-free operation is minimized. *see supra* §VII(A)(2); Ex. 1003, ¶¶304-305.

[FIG. 3]



Like Yuushiro, Bosch confirms that it was well-known not only to rely on fuel maps but also on knock detectors to detect knock and actuate a system to eliminate knock (e.g., the DI system of Rubbert and Yuushiro). Ex. 1031, 465; Ex. 1003, ¶310.

5. *Claim 2: The fuel management system of claim 1 where as torque is increased the fraction of fuel that is directly injected is increased to the value that prevents knock.*

Rubbert teaches a changing ratio between the amount of DI fuel and PI fuel in high load conditions, and Yuushiro discloses that as load increases in the reference load zone, the quantity of DI fuel likewise increases. *See supra* §VII(B)(4); Ex. 1007, 1:31-34; Ex. 1006, ¶[0039], FIG. 3 (illustrating as load increases in the reference load zone, the quantity of DI fuel (Qd) increases); Ex. 1003, ¶¶306-08.

6. *Claim 3: The fuel management system of claim 1 where active control using a knock detector is used to change the amount of fuel that is directly injected as torque is increased.*

Rubbert and Yuushiro are silent regarding the use of a knock sensor to control DI, but a POSITA would understand that knock sensors were known and commonly used to control knock. Ex. 1003, ¶309.

Bosch discloses that knock sensors are used to prevent knock in internal-combustion engines by adjusting the engine by means of an actuator. Ex. 1031, 464-65; Ex. 1003, ¶310. Bosch provides that one such actuator may include ignition timing but was not limited to such. Ex. 1031, 465; Ex. 1003, ¶310. A POSITA would have understood that the actuator could have been used with any anti-knock measure, including DI as taught by Rubbert and Yuushiro. Ex. 1003, ¶310. A POSITA would have understood Bosch to teach the use of a knock sensor to control DI in the engines of Rubbert and Yuushiro. *Id*.

7. Claim 4: The fuel management system of claim 1 or 2 where open loop control using a lookup table is also used to change the amount of fuel that is directly injected as torque is increased.

A POSITA would have understood that the lookup table of Claim 4 was equivalent to a fuel map and that both provide open loop control. Ex. 1003, ¶312. Given that Rubbert explicitly confirmed that its fuel injection amounts were based on load, a POSITA would have been motivated to select a known fuel map that follows Rubbert's teachings and provides specific quantities of PI and DI fuel in the same way as Rubbert to achieve the stated benefit of knock prevention. Ex. 1003, ¶314. A POSITA would have relied on the teachings of Yuushiro, exemplified by its fuel map. Ex. 1006, ¶[0039]; Ex. 1003, ¶¶314-16; *see supra* §VII(A)(7).

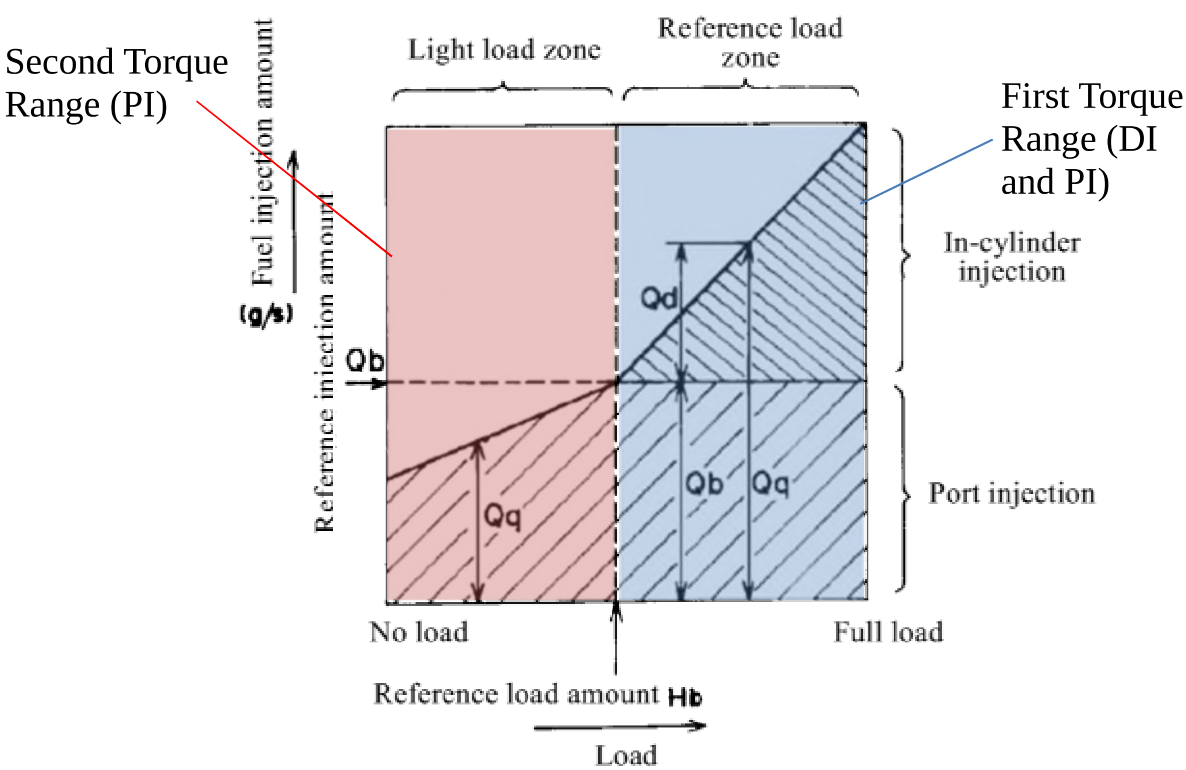
8. Claim 5: The fuel management system of claim 4 where a predetermined correlation between knock resistance and fraction of fuel provided by direct injection is employed.

Yuushiro discloses a fuel map and, therefore, open loop control. Ex. 1006, ¶[0038]; *see supra* §VII(B)(7). Indeed, Yuushiro discloses the purpose of its fuel map is to use DI to eliminate knock. Ex. 1006, ¶[0039]. Further, a POSITA would understand that open loop control relies on a predetermined correlation between knock resistance and the amount of DI fuel used. Ex. 1003, ¶¶317-19.

9. Claim 7: The fuel management system of claim 1 where only port fuel injection is used in a second range of torque.

Yuushiro discloses using PI alone in the light load zone. *See supra* §VII(B)(4); Ex. 1006, ¶¶[0012], [0039], FIG. 3; Ex. 1003, ¶¶320-23.

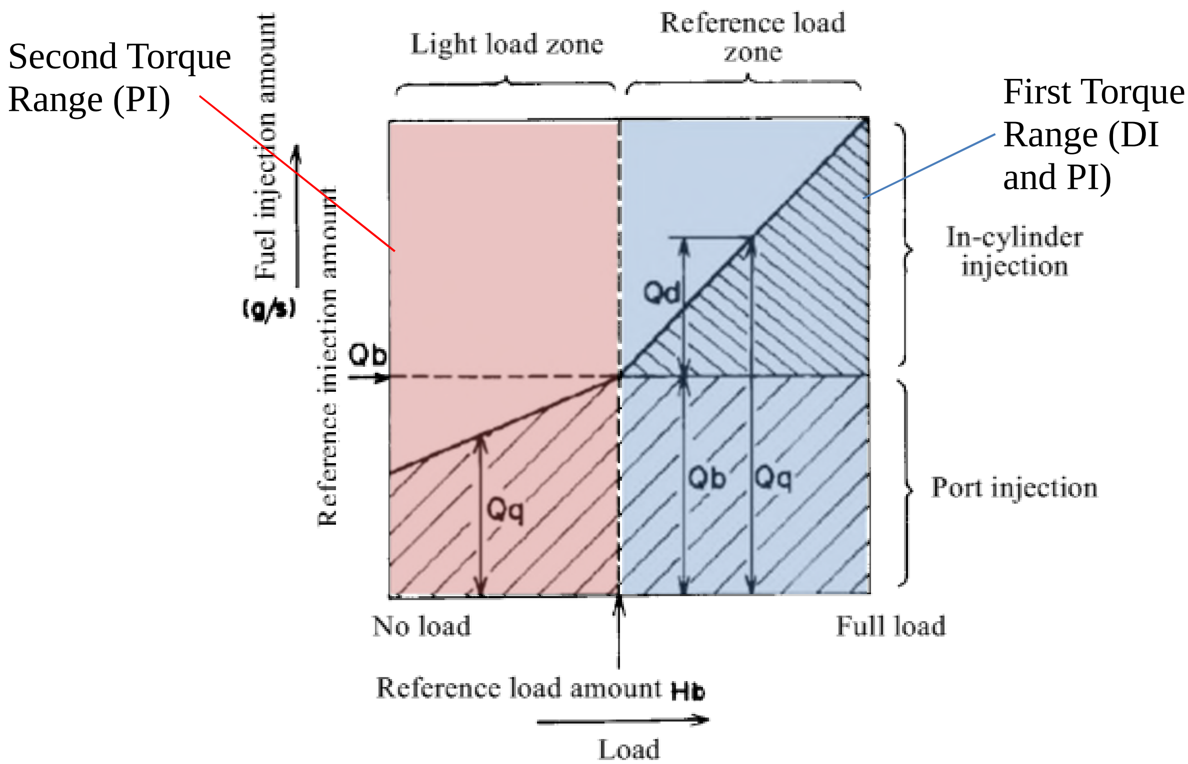
[FIG. 3]



> ***10. Claim 8: The fuel management system of claim 7 where as the torque increases beyond the highest value of torque in the second range of torque, the engine operates in the first range of torque.***

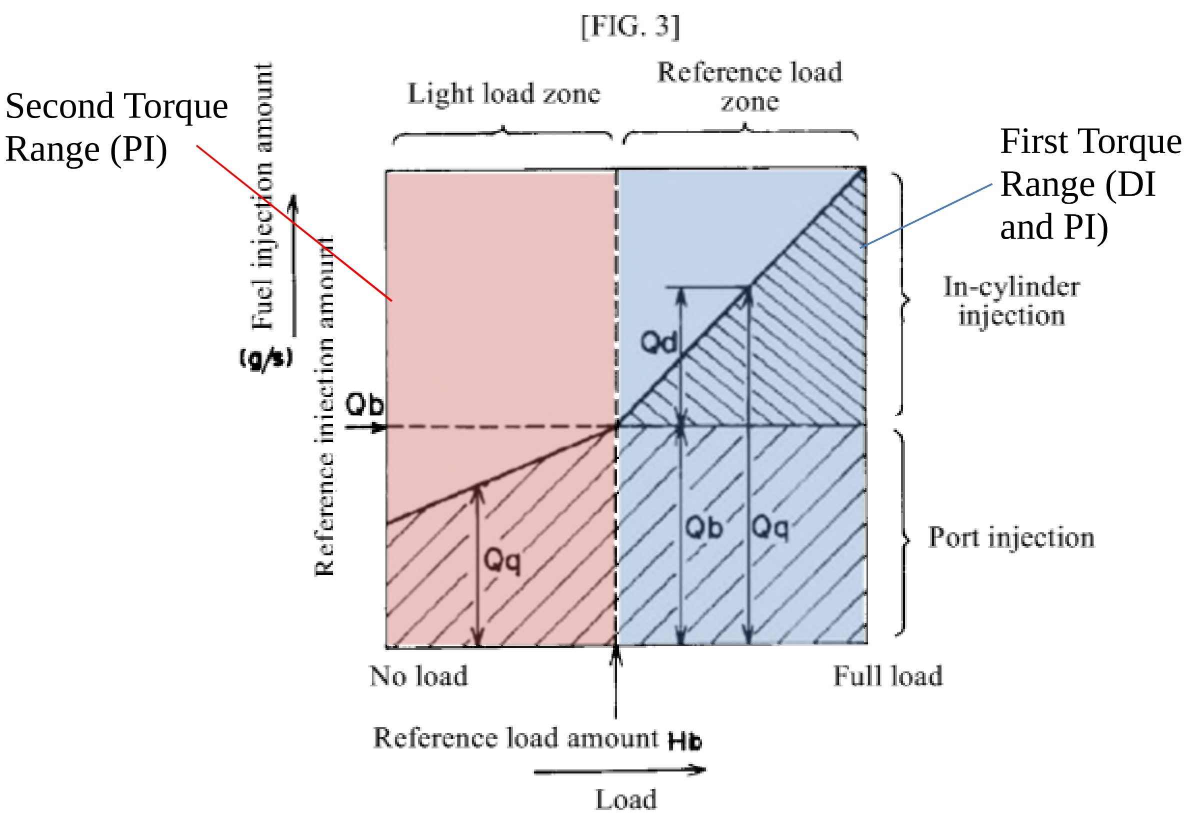
Rubbert and Yuushiro both disclose transitioning from mostly PI and PI only, respectively, at low loads to a mixture of PI and DI with proportionately more DI at higher loads. *See supra* §VII(B)(4); Ex. 1007, 1:49-2:8; Ex. 1006, ¶[0039], FIG. 3 (transitioning from light load zone to reference load zone at reference load amount Hb); Ex. 1003, ¶¶324-27.

[FIG. 3]



11. Claim 10: The fuel management system of claim 7 where the highest torque in the second torque range is the highest torque at which knock-free operation can be obtained with port fuel injection alone.

Yuushiro discloses using PI alone in the light load zone. *See supra* §VII(B)(4); Ex. 1006, ¶¶[0012], [0039], FIG. 3; Ex. 1003, ¶¶328-331.



12. Claim 11: The fuel management system of claim 7 where when spark retard is employed to enable operation with port fuel injection alone where it would not otherwise be used and where the spark retard is controlled by sensed information.

The recitation "where when spark retard is employed to enable operation with port fuel injection alone where it would not otherwise be used" is unclear and fails to modify or add substance to Claim 11. Ex. 1003, ¶332; *see In re Packard,* 751 F.3d 1307, 1313 (Fed. Cir. 2014). As such, it should not be given any patentable weight. Ex. 1036, 19 ("*See* Claim 7").

Irrespective, Yuushiro discloses using PI alone in the light load zone that is defined based on a reference load Hb. *See supra* §VII(B)(3); Ex. 1006, ¶¶[0012], [0039]; Ex. 1003, ¶¶334-36. A POSITA would have understood that adding spark retard to the engine of Rubbert and Yuushiro would result in reduced combustion knock. Ex. 1003, ¶340.

Bosch teaches that engines are damaged by combustion knock. Ex. 1031, 464; Ex. 1003, ¶338. Bosch discloses that it was "customary" as of 1993 to use spark retard to eliminate combustion knock. Ex. 1031, 360; Ex. 1003, ¶338. Bosch further discloses determining the optimum parameters for ignition timing, e.g., whether to employ spark retard based on a sensed parameter, including intake-manifold pressure. Ex. 1031, 472; Ex. 1003, ¶338.

A POSITA would have understood that adding spark retard to the engine of Rubbert and Yuushiro would result in reduced combustion knock. Ex. 1003, ¶340. A POSITA would have understood ignition timing control, e.g., whether to employ spark retard, based on a sensed parameter, including intake-manifold pressure, which is related to torque. *Id*. A POSITA would have further understood the use of a knock sensor to control DI as a manipulated variable to suppress knock. *Id*. [8]

In a spark ignition engine, when considering the fuel map of Yuushiro, retarding the spark would increase the knock limit value of Hb because the mixture would experience later ignition, as taught by Bosch, and, hence, lower temperatures and pressures that reduce the propensity for autoignition. Ex. 1003, ¶341. This would increase the value of Qb and, thus, the range of torques where PI alone would be used is increased. *Id*., ¶342. Yuushiro states that the DI fuel Qd = Qq-Qb, where Qq is the total fuel injected. *Id*. A POSITA would understand (1) that Qd would thus no longer be needed in some torque ranges and (2) Qd would be reduced in other torque ranges. *Id*. These relationships are evident in the fuel map in FIG. 3 of Yuushiro.

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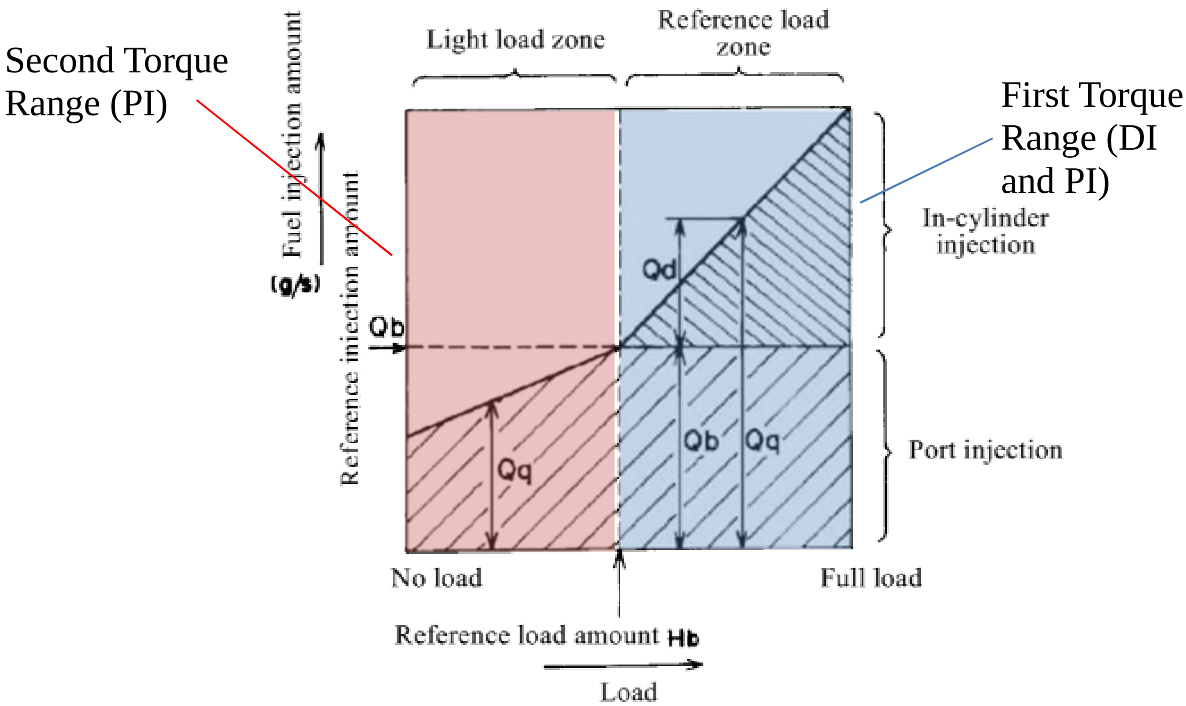
[8] In the litigation, Patent Owner states: "It can be inferred that, for knock control, Ford employs spark retard and reduces the amount of fuel that is introduced into the cylinder by the first fueling system (DI) such that knock control can be implemented without elevated soot emissions." Ex. 1036, 12.

[FIG. 3]



13. Claim 12: The fuel management system of claim 7 where spark retard is employed so that port fuel injection alone can be used where it would not otherwise be used.

The combination of Rubbert, Yuushiro, and Bosch discloses using spark retard such that PI alone can be used when it would not otherwise be used. *See supra* §VII(B)(12); Ex. 1006, ¶¶[0012], [0039]; Ex. 1031, 360, 464, 472; Ex. 1003, ¶¶345-53.

14. Claim 13: The fuel management system of claim 1 where spark retard is used to reduce the fraction of fuel that is provided by direct injection.

The combination of Rubbert, Yuushiro, and Bosch discloses using spark retard to reduce the amount of DI used. *See supra* §VII(B)(12); Ex. 1007, 1:49-2:8; Ex. 1031, 360, 464, 472; Ex. 1003, ¶¶354-61.

15. Claim 14: The fuel management system of claim 1 where the amount of directly injected fuel is minimized throughout the first torque range.

As is discussed with respect to Claim 1, Yuushiro discloses minimizing the amount of DI fuel throughout the reference load zone, which is the first torque range. *See supra* §VII(B)(4); Ex. 1006, ¶[0039]; Ex. 1003, ¶¶362-65; *see also* Ex. 1036, 56 *see also* Ex. 1036, 27.

16. Claim 15: The fuel management system of claim 1 where the amount of directly injected fuel is minimized from zero torque to the highest torque in the first torque range.

As is discussed with respect to Claim 1, Yuushiro discloses minimizing the amount of DI fuel throughout the light load and reference load zones, including at zero load. The light load zone and the reference load zone are the first and second torque ranges, respectively. *See supra* §VII(B)(4); Ex. 1006, ¶¶[0012], [0039]; Ex. 1003, ¶¶366-69; *see also* Ex. 1036, 30.

17. Claim 16: The fuel management system of claim 1 where there is third torque range where the highest torque is the highest torque in the first torque range of the operation and where within the third torque range as torque is increased the fraction of fuel provided by direct injection is changed to the value needed to prevent knock.

The third torque range can be interpreted to be the same as the first torque range. Ex. 1003, ¶370. Rubbert and Yuushiro have been shown above to disclose that the fraction of fuel provided by DI is changed to the value needed to prevent knock in the first torque range and, thus, for the same reasons disclose Claim 16. *See supra* §VII(B)(4); Ex. 1007, 1:31-34; Ex. 1006, FIG. 3, ¶[0039]; Ex. 1003, ¶¶370-73.

18. Claim 17: The fuel management system of claim 9 or 16 where the engine is turbocharged.

Claim 17 is challenged only on the basis of its dependency from Claim 16. Ex. 1003, ¶374; *see supra* §VII(A)(15).

Rubbert discloses a spark ignition engine but is silent regarding the spark ignition engine being turbocharged. Ex. 1003, ¶¶375-76. A POSITA would have understood that Rubbert is compatible with turbocharging and does not exclude the possibility of turbocharged engines, particularly given that turbochargers were a major focus (along with DI) at the time Rubbert was filed. Ex. 1003, ¶376. Indeed, Bosch lists turbocharged engines as one type of reciprocating-piston engine with internal combustion. Ex. 1031, 372-374; Ex. 1003, ¶376. The ’166 Patent admits that turbocharging was a well-known technique to reduce the displacement of engines while maintaining desired power. Ex. 1001, 1:41-48 (citing Ex. 1032); Ex. 1003, ¶376. As such, turbocharged engines were well-known.

19. Claim 18: The fuel management system of claim 16 where the amount of direct injection is minimized.

As is discussed with respect to Claim 1, Yuushiro discloses minimizing the amount of DI fuel injected. *See supra* §VII(B)(4); Ex. 1006, ¶¶[0012], [0039]; Ex. 1003, ¶¶378-81; *see also* Ex. 1036, 35.

20. Claim 19 [19.Pre]: A fuel management system for a turbocharged spark ignition engine which utilizes port fuel injection and also utilizes direct fuel injection;

Claim 19 is substantially similar to Claims 1, 2, 7, 8, and 17 and is likewise disclosed. Specifically, Claim 19.Pre is substantially the same as 1.Pre. *See supra* §§VII(B)(2), (18); Ex. 1003, ¶¶382-87. Claim 19.Pre differs from 1.Pre in that it includes a "turbocharged" engine. A "turbocharged" engine is disclosed by the combination shown with respect to Claim 17. *Id.*

21. Claim 19 [19.A]: and where there is a first range of torque throughout which direct injection and port injection are used at the same value of torque;

Claim 19.A is substantially similar to 1.A and is likewise disclosed. *See supra* §VII(B)(3); Ex. 1003, ¶¶388-91.

22. Claim 19 [19.B]: and wherein as torque is increased the fraction of fuel that is directly injected is increased to a value that prevents knock;

Claim 19.B is substantially similar to 1.B and 2 and is likewise disclosed. *See supra* §VII(B)(4), (5); Ex. 1003, ¶¶392-95.

23. Claim 19 [19.C]: and where there is a second range of torque where only port fuel injection is used;

Claim 19.C is substantially similar to Claim 7 and is likewise disclosed. *See supra* §VII(B)(3), (9); Ex. 1003, ¶¶396-99.

24. Claim 19 [19.D]: and where when torque exceeds the highest torque in the second range of torque the engine operates in the first range of torque.

Claim 19.D is substantially similar to Claim 8 and is likewise disclosed. *See supra* §VII(B)(3), (10); Ex. 1003, ¶¶400-03.

25. Claim 20: The fuel management system of claim 19 where the second torque range starts at zero torque.

Yuushiro discloses a light load zone (i.e. a second torque range) starting at zero load (i.e. torque) in which PI alone is used. *See supra* §VII(B)(4); Ex. 1006, FIG. 3 (illustrating light load zone starting at no load); Ex. 1003, ¶¶404-07.

26. Claim 21: The fuel management system of claim 19 or 20 where the highest value of torque in the second region of torque is the highest value of torque at which direct injection is not needed to prevent knock.

Claim 21 is a multiple dependent claim, depending from both Claims 19 and 20, both of which are challenged herein. Thus, Claim 21 is challenged in the context of its dependency from Claims 19 and 20.

Rubbert and Yuushiro both disclose transitioning from mostly PI and PI only, respectively, at low loads to a mixture of PI and DI with proportionately more DI at higher loads. *See supra* §VII(B)(4); Ex. 1007, 1:49-2:8; Ex. 1006, FIG. 3, ¶[0039]; Ex. 1003, ¶¶408-12.

27. Claim 22 [22.PRE]: A spark ignition engine

Claim 22 is substantially similar to Claims 1, 2, and 11 and is likewise disclosed. Specifically, Claim 22.Pre is substantially the same as 1.Pre. *See supra* §VII(B)(2); Ex. 1003, ¶¶413-15. Claim 22.Pre differs from 1.Pre in that it only requires a spark ignition engine.

28. Claim 22 [22.A]: where port fuel injection and direct injection are used and the fraction of fuel provided by direct injection is increased so as to prevent knock that would otherwise occur; and

Claim 22.A is substantially similar to 1.Pre, 1.B, and 2 and is likewise disclosed. *See supra* §§VII(B)(2), (4), (5); Ex. 1003, ¶¶416-20.

29. Claim 22 [22.B]: where spark retard is employed to enable reduction of the amount of direct injection that would otherwise be employed.

Claim 22.B is substantially similar to Claim 11 and is likewise disclosed. *See supra* §VII(B)(12); Ex. 1003, ¶¶421-28.

30. Claim 23: The spark ignition engine of claim 22 where the engine is operated with port fuel injection alone at values of torque where port fuel injection alone would not otherwise be employed.

As is discussed with respect to Claim 11, the combination of Rubbert, Yuushiro, and Bosch discloses using spark retard such that PI alone can be used when it would not otherwise be used. *See supra* §VII(B)(12); Ex. 1006, ¶¶[0012], [0039]; Ex. 1031, 360, 464, 472; Ex. 1003, ¶¶429-36.

31. Claim 24: The spark ignition engine of claim 22 or 23 where the spark retard is controlled by detection of knock and by information from another sensed parameter.

As is discussed with respect to Claim 11, the combination of Rubbert, Yuushiro, and Bosch discloses using spark retard controlled by information from another sensed parameter, e.g., intake-manifold pressure. *See supra* §VII(B)(12); Ex. 1031, 360, 464, 472; Ex. 1003, ¶¶442-49.

With regard to knock, Bosch discloses a knock sensor. Ex. 1031, 464; Ex. 1003, ¶444. Further, "[t]he (closed-loop) control circuit adjusts the engine by means of an actuator and eliminates the knock." *Id*. While Bosch's knock sensor can be used with any engine adjustment that reduces knock, Bosch discloses that "[i]gnition timing is an especially effective manipulated variable, as it permits the most rapid corrections." *Id*.

32. Claim 26: The spark ignition engine of claim 22 or 23 where without the application of the spark retard the engine is operated with both port fuel injection and direct injection at the same value of torque.

It would have been obvious to a POSITA to retard spark in order to delay ignition, thereby allowing less time for autoignition before the flame front arrives and preventing knock. Ex. 1003, ¶450. Without application of spark retard, the claim is substantially similar to claim 1. Rubbert and Yuushiro disclose operating an engine "with both port fuel injection and direction injection at the same value of torque." *See supra* §VII(B)(3); Ex. 1007, 1:31-34, 1:44-2:8; Ex. 1006, ¶¶[0012], [0038]-[0039]; Ex. 1003, ¶¶450-54; *see also* Ex. 1036, 56.

33. Claim 27: The spark ignition engine of claim 22 where without the employment of the spark retard the fraction of fuel provided by direct injection increases with increasing torque.

It would have been obvious to a POSITA to retard spark in order to delay ignition, thereby allowing less time for autoignition before the flame front arrives and preventing knock. Ex. 1003, ¶455. Without application of spark retard, Rubbert and Yuushiro disclose that "the fraction of fuel provided by direct injection increases with increasing torque." *See supra* §VII(B)(5); Ex. 1007, 2:4-8; Ex. 1006, FIG. 3, ¶[0039]; Ex. 1003, ¶¶455-58; *see also* Ex. 1036, 57.

34. Claim 28: The spark ignition engine of claim 22 where there is a first torque range throughout which port fuel injection and direct injection are used at the same torque and wherein the fraction of fuel provided by direct injection increases with increasing torque in such a way as to enable knock-free operation and where there is a second torque range where only port fuel injection is used and where when the torque exceeds the highest torque in this range, the engine operates in the first torque range.

Claim 28 is substantially similar to 1.A, 2, 7, and 8 and is likewise disclosed. *See supra* §§VII(B)(3), (5), (9), (10); Ex. 1007, 1:31-34, 1:44-2:8; Ex. 1006, ¶¶[0012], [0038]-[0039]; Ex. 1003, ¶¶459-68.

35. Claim 29: The spark ignition engine of claim 28 where the engine operates in the second torque range between zero torque and the highest torque in the second torque range.

Claim 29 is substantially similar to Claims 10 and 20 and is likewise disclosed. *See supra* §§VII(B)(11), (25); Ex. 1007, 1:49-2:8; Ex. 1006, ¶¶[0012], [0038]-[0039]; Ex. 1003, ¶¶469-72.

36. Claim 30: The spark ignition engine of claim 22 where spark retard is used to reduce the amount of direct injection to zero from what it would otherwise have been.

As is discussed with respect to Claim 11, the combination of Rubbert, Yuushiro, and Bosch discloses using spark retard to reduce the amount of DI used, including to zero such that PI only is used. *See supra* §VII(B)(12); Ex. 1007, 1:49-2:8; Ex. 1006, ¶¶[0012], [0039]; Ex. 1031, 360, 464, 472; Ex. 1003, ¶¶473-80.

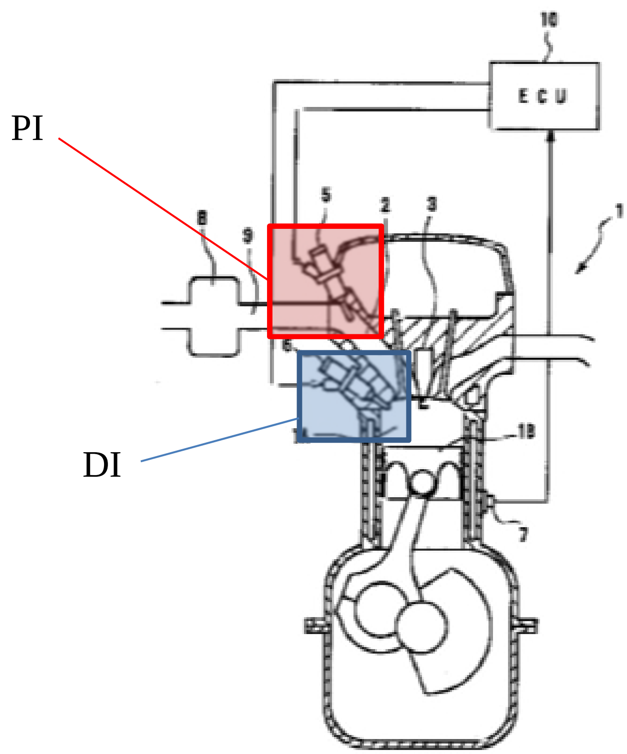
C. Ground 3: Claims 1-5, 7, 8, 10-24, 26-30 are Unpatentable Under 35 U.S.C. §103 over Kinjiro and Bosch

1. Overview of Ground 3

i. Overview of Kinjiro and Bosch

Kinjiro is directed to a spark ignition engine that relies on PI and DI. Ex. 1008, ¶¶[0010]-[0011], FIG. 1(below); Ex. 1003, ¶488.

[FIG. 1]



A POSITA would have understood that Kinjiro discloses transitioning from PI alone at low load conditions to a split injection mode by directly injecting a proportion of the fuel at higher loads. Ex. 1008, ¶¶[0020]-[0021]; Ex. 1003, ¶488.

Kinjiro does not explicitly disclose the use of spark retard in suppressing knock although it is suggested throughout. Kinjiro is also silent whether its spark ignition engine is turbocharged or naturally aspirated. A POSITA would have understood that Kinjiro does not exclude the possibility its engine being turbocharged. Ex. 1003, ¶489. Moreover, while Kinjiro discloses "split injection control" in the control strategy, Kinjiro is silent with respect to certain known features of open loop control, such as a lookup table. Irrespective, spark retard, turbocharging, and open loop control were well-known in fuel management systems, which is illustrated by Bosch. Ex. 1031, 360, 372-74, 441, 464-65; Ex. 1003, ¶¶489-90.

Bosch discloses the use of turbochargers. Ex. 1031, 372-74. Bosch also discloses that it was "customary" as of 1993 to use spark retard to eliminate combustion knock. Ex. 1031, 360. Bosch also teaches that "[o]pen-loop control systems feature processes in which one or several input variable are employed for adjustments to one or several output variables." Ex. 1031, 164. Bosch further teaches that "[a]n open control loop can be a subordinate part of another system, and can interact in any fashion with other systems." *Id*. Bosch teaches that fueling may also be controlled by an ECU in either closed loop or open loop control. Ex. 1031, 441.

ii. Motivation to Combine

Kinjiro does not explicitly disclose the use of spark retard in suppressing knock although it is suggested throughout the disclosure. Regardless, a POSITA would have understood that the use of spark retard would be beneficial to protect the engine and reduce the amount of fuel that is directly injected and, thus, improve efficiency and reduce emissions. Ex. 1003, ¶489. A POSITA would have sought out the relevant implementation details. *Id.*

A POSITA would have looked to Bosch, which confirms that a POSITA would rely on spark retard to improve engine operation in a known way. Ex. 1031, 360; Ex. 1003, ¶489. Bosch, like Kinjiro, also discloses the use of a knock sensor to adjust engine variables to eliminate knock, including but not limited to spark retard. Ex. 1031, 464-65; Ex. 1003, ¶489. A POSITA would have understood from Bosch that Kinjiro's knock sensor would have been applied to the management of other engine variables that influence knock, including DI quantity and spark retard. Ex. 1003, ¶489. Indeed, both spark retard and DI perform in a similar way by reducing the exposure of the unburned remaining mixture to sustained high temperature, thereby avoiding knock. *Id*. Thus, a POSITA would have expected the combined system to be successful given that both Bosch and Kinjiro teach a POSITA that DI and spark retard are well-known techniques for knock management. *Id*.

Kinjiro is also silent whether the spark ignition engine is turbocharged or naturally aspirated. A POSITA would have understood that Kinjiro does not exclude the possibility its engine being turbocharged. Ex. 1003, ¶489. Turbochargers were a major focus (along with DI) at the time Kinjiro was filed. *Id*. Bosch confirms. Ex. 1031, 372-374. A POSITA would have understood that there was a market desire in 2004 to improve fuel economy and reduce emissions. *Id*.; Ex. 1032, 3. As such, a POSITA would have responded to these known conditions and would have understood Kinjiro to include a turbocharger to provide improved fuel economy. Ex. 1003, ¶489. Indeed, the ’166 Patent admits that turbocharging was a well-known technique to reduce the displacement of engines while maintaining desired power. Ex. 1001, 1:41-48 (citing Ex. 1032); Ex. 1003, ¶489. Thus, given that Kinjiro is compatible with turbocharging, a POSITA would have looked to a reference text, e.g., Bosch, to add turbocharging to Kinjiro’s engine to provide improved fuel economy and would have had a reasonable expectation of success in doing so. Ex. 1003, ¶489.

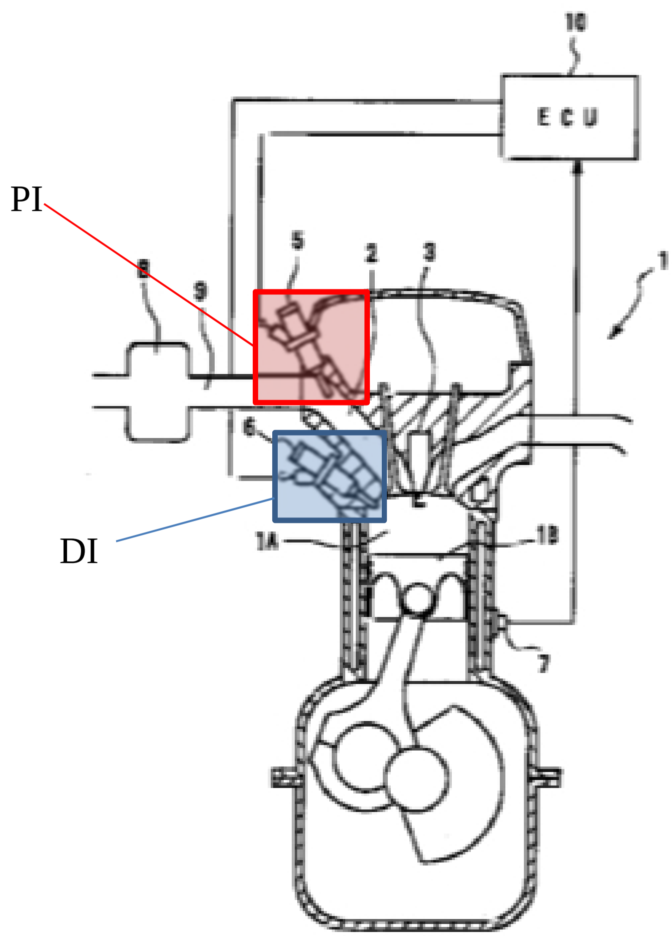
Kinjiro discloses the use of closed loop control with a knock sensor. Ex. 1008, ¶[0013]; Ex. 1003, ¶490. While Kinjiro discloses “split injection control” in the control strategy, Kinjiro is silent with respect to certain known features of open loop control, such as a lookup table. Ex. 1008, ¶[0014]; Ex. 1003, ¶490. However, a POSITA would understand that Kinjiro’s closed loop control system is a well-known engine control strategy often used in conjunction with open loop control. Ex. 1003, ¶490. A POSITA would have further understood that relying on one strategy, such as closed loop control with a knock sensor alone, would result in reduced efficiency and output. *Id*. Thus, a POSITA would have looked to a system that included open loop control alone in conjunction with closed loop control, e.g., Bosch. *Id*.

Bosch teaches open loop control Ex. 1031, 164; Ex. 1003, ¶490. Bosch confirms that a POSITA would have had a reasonable expectation of success in the combination because Bosch confirms that open loop and closed loop are operated to together. *Id.* For example, in one open loop control system, Bosch teaches that ignition point (e.g., spark retard) can be controlled based on variables including engine speed, intake-manifold pressure, and engine temperature. Ex. 1031, 167. Bosch teaches that fueling may also be controlled by an ECU in either closed loop or open loop control. Ex. 1031, 441. Bosch teaches that a coding switch allows selection between closed loop or open loop control. Ex. 1031, 441. It thus would have been obvious to a POSITA to include the open loop control strategies discussed by Bosch when implementing Kinjiro in order to maintain additional control over engine variables, including ignition point. Ex. 1003, ¶490.

2. Claim 1: [1.Pre]

To the extent the preamble of Claim 1 is limiting, Kinjiro discloses a spark ignition engine (shown below in Figure 1). Ex. 1008, ¶¶[0011]-[0012]. Kinjiro's engine comprises PI and DI. Ex. 1008, ¶¶[0010]-[0011]; Ex. 1003, ¶492. Information detected by a knock sensor is input to an ECU, which sets an operation control signal for each injector. Ex. 1008, ¶[0013]; Ex. 1003, ¶492. Kinjiro's system activates DI in response to knocking. Ex. 1008, Abstract, FIG. 5 (illustrating control strategy); Ex. 1003, ¶492.

[FIG. 1]



3. Claim 1: [1.A]

Petitioner interprets Limitation 1.A to mean that DI and PI are both used to fuel the engine at any value of torque in the first torque range. Ex. 1003, ¶494; *see supra* §VII(A)(3).

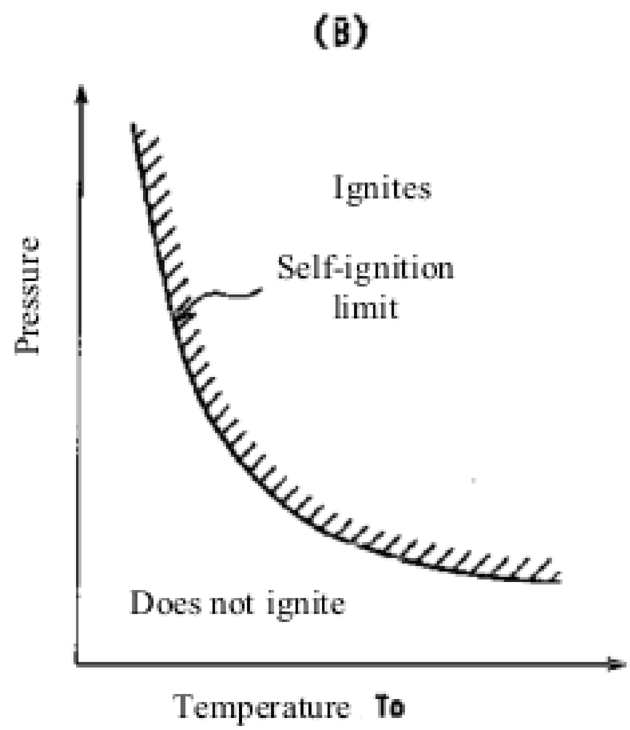
Kinjiro discloses a knock sensor used to define the first torque range (e.g., a range of torques where knock would persist if DI was not used). Ex. 1008, ¶[0012]; Ex. 1003, ¶495. Kinjiro discloses a split injection mode that is activated in response to detected knock, which occurs at or above a specific output torque (e.g., a first torque range). Ex. 1008, ¶¶[0014], [0027]; Ex. 1003, ¶495. In the split injection mode, Kinjiro discloses that fuel injection is performed by both PI and DI. Ex. 1008, ¶[0014]; Ex. 1003, ¶495.

4. Claim 1: [1.B]

Kinjiro discloses a knock sensor used to define the first torque range (e.g., a range of torques where knock would persist if DI was not used). Ex. 1008, ¶[0012]; Ex. 1003, ¶497. Information detected by the knock sensor is input to an ECU, which sets an operation control signal for each of the DI and PI injectors. Ex. 1008, ¶[0014]; Ex. 1003, ¶497. Kinjiro discloses two modes of operation. First, Kinjiro discloses a normal operating state. *Id*. In the normal operating state, Kinjiro discloses that when knock has not been detected, the engine is fueled by PI alone (second torque range). *Id.* Where only PI is used, DI fuel is *de facto* minimized. Second, Kinjiro discloses a split injection mode where the engine is fueled by DI and PI (first torque range). *Id*; *see supra* §VII(C)(3). The engine enters the split injection mode when knock is detected in the normal operating state. Ex. 1008, ¶[0014], FIG. 5; Ex. 1003, ¶497. Therefore, the ratio of DI to PI increases (e.g., from no DI to some DI) as operation moves from the first operating state to the split injection mode. *Id*.

Kinjiro discloses that an increase in cylinder temperature during the split injection mode would necessarily lead to an increase in the ratio of DI to PI. Ex. 1003, ¶499.

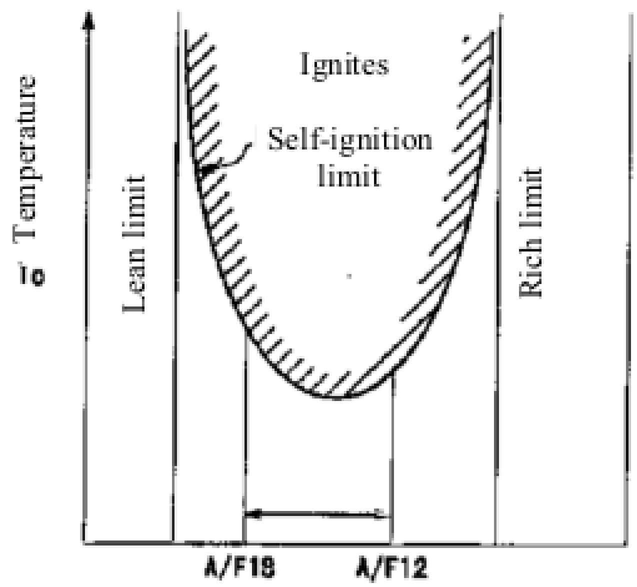
Kinjiro discloses that increased temperature or pressure in the combustion chamber increases the engine's tendency to knock. Ex. 1008, ¶[0002]; Ex. 1003, ¶500. FIG. 6B illustrates that pressure and temperature define a zone in which knocking will occur and a zone in which knocking will not occur. Ex. 1003, ¶500. The knocking occurs in the zone where temperature and/or pressure are higher. *Id*.



In response to an increased tendency to knock, Kinjiro teaches increasing the air/fuel ratio of PI fuel by decreasing the amount of PI fuel and injecting a sufficient amount of DI fuel such that the total air to fuel ratio is stoichiometric or rich. Ex. 1008, Claim 2, ¶¶[0009], [0041]; Ex. 1003, ¶501. To maintain the overall air to fuel ratio as stoichiometric or rich, as PI quantity decreases, DI quantity must increase. Ex. 1008, ¶¶[0009], [0019]; Ex. 1003, ¶501. Thus, Kinjiro teaches that the ratio of DI fuel to PI fuel must increase with increasing cylinder temperature. Ex. 1003, ¶501.

Engine torque is related to the pressure in the cylinder. Thermodynamically, higher temperatures are associated with higher pressures. Ex. 1031, 356, 437. In FIG. 6A below Kinjiro shows that knocking can be avoided with a leaner PI fuel mixture as temperature increases. Ex. 1008, FIG. 6A, ¶[0008]; Ex. 1003, ¶502. The lean mixture in the cylinder is enriched with DI fuel to achieve a stoichiometric air/fuel ratio. Ex. 1008, ¶[0009]. Because temperature increases with increasing torque, Kinjiro teaches in FIG. 6A that a leaner (higher air/fuel ratio) PI fuel mixture should be used at higher torque, requiring an increased ratio of DI fuel to compensate for the leaner PI fuel mixture. *Id*., Ex. 1003, ¶502.

(A) [FIG. 6]



Kinjiro confirms that at a specific air/fuel ratio, DI fuel is minimized. Ex. 1003, ¶503. Kinjiro discloses that the PI fuel is sufficiently lean so that it does not self-ignite. Ex. 1008, ¶[0009]; Ex. 1003, ¶503. Given the lean mixture, Kinjiro supplements the lean mixture with a locally rich mixture from the direct injector. *Id*. Even though the direct injector provides a locally rich mixture, the amount of DI fuel is limited or minimized by the desired air/fuel ratio and the need for the in-cylinder mixture to be a stoichiometric mixture. Ex. 1008, ¶[0018]; Ex. 1003, ¶503; *see also* Ex. 1036, 3.

Like Kinjiro, Bosch confirms that it was well known to rely on open loop control as well as closed loop control to detect knock and actuate a system to eliminate knock (e.g., the DI system of Kinjiro). *See* Ex. 1031, 164, 167, 441; Ex. 1003, ¶519.

5. Claim 2

As is discussed with respect to Claim 1, Kinjiro discloses increasing the fraction of DI fuel to the value that prevents knock when torque is increased. *See supra* §VII(C)(4); Ex. 1008, Claim 2, ¶¶[0009], [0019], [0041]; Ex. 1003, ¶¶504-09.

6. Claim 3

As is discussed with respect to Claim 1, Kinjiro discloses a knock sensor which provides an input to the ECU, which changes the amount of DI fuel as torque increases. *See supra* §VII(C)(4); Ex. 1008, ¶[0012; Ex. 1003, ¶¶510-15.

7. Claim 4

Kinjiro discloses using a knock sensor with the ECU to set an operation control signal for each injector. *See supra* §VII(C)(4), (6); Ex. 1008, ¶[0014]; Ex. 1003, ¶517. Although Kinjiro does not explicitly disclose open loop control, Kinjiro shows "split injection control" in the control strategy. Ex. 1008, FIG. 5; Ex. 1003, ¶517. "Split injection control" is a form of open loop control. *Id.*

Open loop control is explicitly disclosed by Bosch. Ex. 1003, ¶519. Bosch teaches that "[o]pen-loop control systems feature processes in which one or several input variable are employed for adjustments to one or several output variables."

Ex. 1031, 164. A POSITA would understand that such a process includes a lookup table. Ex. 1003, ¶519. Bosch further teaches that "[a]n open control loop can be a subordinate part of another system, and can interact in any fashion with other systems." Ex. 1031, 164. Bosch teaches that fueling may also be controlled by an ECU in either closed loop or open loop control. Ex. 1031, 441. It would have been obvious to a POSITA to modify Kinjiro to include open loop control as discussed by Bosch in order to maintain additional control over engine variables. Ex. 1003, ¶519.

8. Claim 5

Kinjiro does not explicitly teach open loop control. *See supra* §VII(C)(7); Ex. 1008, ¶¶[0012], [0014]; Ex. 1003, ¶520. Bosch discloses open loop control. *See supra* §VII(C)(7); Ex. 1031, 164, 167, 441; Ex. 1003, ¶522. A POSITA would understand that open loop control depends on a predetermined correlation between torque, which is related to knock, and a quantity of fuel. *See supra* §VII(C)(7); Ex. 1003, ¶521.

9. Claim 7

As is discussed with respect to Claim 1, Kinjiro discloses a torque range in which only PI is used when knock is not occurring. *See supra* §VII(C)(4); Ex. 1008, ¶[0014]; Ex. 1003, ¶523.

10. Claim 8

Kinjiro discloses transitioning from PI when knock is not occurring (*i.e.* the second torque range) to a mixture of PI and DI when knock is occurring (*i.e.* the first torque range). *See supra* §§VII(C)(4), (9); Ex. 1008, ¶¶[0014], [0018]-[0021]; Ex. 1003, ¶¶524-25.

11. Claim 10

As is discussed with respect to Claim 1, Kinjiro discloses using PI alone when knock is not occurring (*i.e.* the second torque range). *See supra* §VII(C)(4); Ex. 1008, ¶[0014]; Ex. 1003, ¶526.

12. Claim 11

The recitation "where when spark retard is employed to enable operation with port fuel injection alone where it would not otherwise be used" is unclear and fails to modify or add substance to Claim 11. *See supra* §VII(B)(12).

Kinjiro acknowledges that spark timing can be used to prevent knocking. Ex. 1008, ¶¶[0003], [0033]; Ex. 1003, ¶529. Kinjiro directly addresses spark timing as a tool to avoid knocking and discloses that "conventionally, ignition timing has to be retarded at the time of knocking occurrence." Ex. 1008, ¶[0037]; Ex. 1003, ¶529. A POSITA would understand that the ECU would use information detected by the knock sensor to control ignition timing. Kinjiro also discloses other sensors that provide information to the ECU. Ex. 1008, ¶¶[0033],

Figure 5 (referring to measurements of engine speed and water temperature); Ex. 1003, ¶529.

Bosch teaches the effects spark retard has on ignition (e.g., engine damage). Ex. 1031, 464; Ex. 1003, ¶531. Bosch discloses that it was "customary" as of 1993 to use spark retard to eliminate combustion knock. Ex. 1031, 360. Bosch further discloses determining the optimum parameters for ignition timing, e.g., whether to employ spark retard, based on a sensed parameter, including intake-manifold pressure. Ex. 1031, 472; Ex. 1003, ¶531.

A POSITA would have understood that adding the spark retard of Bosch to the engine of Kinjiro would have resulted in reduced combustion knock. Ex. 1003, ¶533; s*ee supra* §VII(B)(12). Moreover, a POSITA would understand that spark retard would permit the engine of Kinjiro to operate with reduced DI (and therefore proportionally more PI) without altering the propensity of the engine to knock. Ex. 1003, ¶535.

13. Claim 12

As is discussed with respect to Claim 11, the combination of Kinjiro and Bosch discloses using spark retard such that PI alone can be used when it would not otherwise be used. *See supra* §VII(C)(12); Ex. 1008, ¶[0014]; Ex. 1031, 360, 464, 472; Ex. 1003, ¶¶537-44.

14. Claim 13

As is discussed with respect to Claim 11, the combination of Kinjiro and Bosch discloses using spark retard to reduce the amount of DI used. *See supra* §VII(C)(12); Ex. 1008, ¶¶[0003], [0014], [0033], [0037]; Ex. 1031, 360, 464, 472; Ex. 1003, ¶¶545-52.

15. Claim 14

As is discussed with respect to Claim 1, Kinjiro discloses minimizing the amount of DI fuel when knock occurs (i.e. in the first torque range). *See supra* §VII(C)(4); Ex. 1008, ¶¶[0009], [0014], [0018]; Ex. 1003, ¶¶553-54; *see also* Ex. 1036, 27.

16. Claim 15

As is discussed with respect to Claim 1, Kinjiro discloses minimizing the amount of DI fuel both when knock is and is not occurring (i.e. in the first and second torque ranges respectively), including at zero torque. *See supra* §VII(C)(4); Ex. 1008, ¶¶[0009], [0012], [0014], [0018]; Ex. 1003, ¶¶555-56; *see also* Ex. 1036, 30.

17. Claim 16

The third torque range can be interpreted to be the same as the first torque range. Kinjiro has been shown above to disclose that the fraction of fuel provided by DI is changed to the value needed to prevent knock in the first torque range and, thus, for the same reasons discloses Claim 16. *See supra* §VII(C)(4); Ex. 1008, ¶¶[0009], [0012], [0014], [0018]; Ex. 1003, ¶¶557-63.

18. Claim 17

Because Claim 9 is not challenged herein, Claim 17 is challenged only on the basis of its dependency from Claim 16. Ex. 1003, ¶564; *see supra* §VII(A)(15).

While Kinjiro does not explicitly teach a turbocharged engine, a POSITA would have understood that Kinjiro does not exclude the possibility of turbocharged engines. Ex. 1003, ¶566. Indeed, Bosch lists turbocharged engines as one type of reciprocating-piston engine with internal combustion. Ex. 1031, 372-374; Ex. 1003, ¶566. The '166 Patent admits that turbocharging was a well-known technique to reduce the displacement of engines while maintaining desired power. Ex. 1001, 1:41-48. As such, turbocharged engines were well-known.

19. Claim 18

As is discussed with respect to Claim 1, Kinjiro discloses minimizing the amount of DI fuel injected. *See supra* §VII(C)(4); Ex. 1008, ¶¶[0009], [0014], [0018]; Ex. 1003, ¶¶567-68; *see also* Ex. 1036, 35.

20. Claim 19 [19.Pre]

Claim 19 is substantially similar to Claims 1, 2, 7, 8, and 17 and is likewise disclosed. Specifically, Claim 19.Pre is substantially the same as 1.Pre. *See supra* §§VII(C)(2), (18); Ex. 1003, ¶¶569-572. Claim 19.Pre differs from 1.Pre in that it includes a “turbocharged” engine. A “turbocharged” engine is disclosed by the combination shown with respect to Claim 17. *Id.*

21. Claim 19 [19.A]

Claim 19.A is substantially similar to 1.A and is likewise disclosed. *See supra* §VII(C)(3); Ex. 1003, ¶¶573-74.

22. Claim 19 [19.B]

Claim 19.B is substantially similar to 1.B and 2 and is likewise disclosed. *See supra* §VII(C)(4), (5); Ex. 1003, ¶¶575-80.

23. Claim 19 [19.C]

Claim 19.C is substantially similar to Claim 7 and is likewise disclosed. *See supra* §VII(C)(3), (9); Ex. 1003, ¶581.

24. Claim 19 [19.D]

Claim 19.D is substantially similar to Claim 8 and is likewise disclosed. *See supra* §VII(C)(3), (10); Ex. 1003, ¶¶582-83.

25. Claim 20

As is discussed with respect to Claim 1, Kinjiro discloses a second torque range starting at zero torque in which PI alone is used because knock is not occurring. *See supra* §VII(C)(4); Ex. 1008, ¶[0014]; Ex. 1003, ¶584.

26. Claim 21

As is discussed with respect to Claim 1, Kinjiro discloses transitioning from PI only when knock is not occurring to a mixture of PI and DI when knock is occurring, *i.e.* at higher torque. *See supra* §VII(C)(4); Ex. 1008, ¶[0014]; Ex. 1003, ¶¶585-86.

27. Claim 22 [22.PRE]

Claim 22 is substantially similar to Claims 1, 2, and 11 and is likewise disclosed. Specifically, Claim 22.Pre is substantially the same as 1.Pre. *See supra* §VII(C)(2); Ex. 1003, ¶¶587-88. Claim 22.Pre differs from 1.Pre in that it only requires a spark ignition engine.

28. Claim 22 [22.A]

Claim 22.A is substantially similar to 1.Pre, 1.B, and 2 and is likewise disclosed. *See supra* §§VII(C)(2), (4), (5); Ex. 1003, ¶¶589-95.

29. Claim 22 [22.B]

Claim 22.B is substantially similar to Claim 11 and is likewise disclosed. *See supra* §VII(C)(12); Ex. 1003, ¶¶596-603.

30. Claim 23

As is discussed with respect to Claim 11, the combination of Kinjiro and Bosch discloses using spark retard such that PI alone can be used when it would not otherwise be used. *See supra* §VII(C)(12); Ex. 1008, ¶¶[0003], [0014], [0033], [0037]; Ex. 1031, 360, 464, 472; Ex. 1003, ¶¶604-12.

31. Claim 24

As is discussed with respect to Claim 11, the combination of Kinjiro and Bosch discloses using spark retard controlled by information from another sensed parameter, e.g., intake-manifold pressure. *See supra* §VII(C)(12); Ex. 1008, ¶¶[0003], [0014], [0033], [0037]; Ex. 1031, 360, 464, 472; Ex. 1003, ¶¶613-22.

With regard to knock, Bosch discloses a knock sensor. Ex. 1031, 464; Ex. 1003, ¶618. Further, "[t]he (closed-loop) control circuit adjusts the engine by means of an actuator and eliminates the knock." *Id*. While Bosch's knock sensor can be used with any engine adjustment that reduces knock, Bosch discloses that "[i]gnition timing is an especially effective manipulated variable, as it permits the most rapid corrections." *Id*.

32. Claim 26

It would have been obvious to a POSITA to retard spark in order to delay ignition, thereby allowing less time for autoignition before the flame front arrives and preventing knock. Ex. 1031, 464; Ex. 1003, ¶623. Without application of spark retard, Kinjiro discloses operating an engine "with both port fuel injection and direction injection at the same value of torque." *See supra* §VII(C)(3); Ex. 1008, ¶¶[0008], [0012]-[0014], [0017], [0027]-[0028]; Ex. 1003, ¶¶623-25; *see also* Ex. 1036, 56.

33. Claim 27

It would have been obvious to a POSITA to retard spark in order to delay ignition, thereby allowing less time for autoignition before the flame front arrives and preventing knock. Ex. 1031, 464; Ex. 1003, ¶626. Without application of spark retard, Kinjiro discloses that "the fraction of fuel provided by direct injection increases with increasing torque." *See supra* §VII(C)(5); Ex. 1008, Claim 2, ¶¶[0002], [0009], [0012], [0014], [0019], [0041]; Ex. 1003, ¶¶626-32; *see also* Ex. 1036, 57.

34. Claim 28

Claim 28 is substantially similar to Limitation 1.A and Claims 2, 7, and 8 and is likewise disclosed. *See supra* §§VII(C)(3), (5), (9), (10); Ex. 1008, ¶¶[0002], [0008]-[0009], [0012]-[0014], [0017]-[0021], [0027]-[0028], [0041]; Ex. 1003, ¶¶633-39.

35. Claim 29

Claim 29 is substantially similar to Claims 10 and 20 and is likewise disclosed. *See supra* §§VII(C)(11), (25); Ex. 1008, ¶¶[0014], [0018]-[0021]; 1003, ¶¶640-41.

36. Claim 30

As is discussed with respect to Claim 11, the combination of Kinjiro and Bosch discloses using spark retard to reduce the amount of DI used, including to zero such that PI only is used. *See supra* §VII(C)(12); Ex. 1008, ¶¶[0003], [0014], [0033], [0037]; Ex. 1031, 360, 464, 472; Ex. 1003, ¶¶642-49.

D. No Ground is Redundant

Ground 1 challenges Claims 1-5, 7, 8, 10, 14-21 based on Kobayashi and Yuushiro. Ground 2 is based on Rubbert, Yuushiro, and Bosch, which illustrate that the generic concept of PI and DI was known in spark ignition engines. Finally, Ground 3 is based on Kinjiro and Bosch and further illustrates the known use of closed loop control in a spark ignition engine with DI and PI.

VIII. CONCLUSION

Petitioner respectfully requests cancellation of the challenged claims.

IX. MANDATORY NOTICES UNDER 37 C.F.R. §42.8

A. Real Party in Interest Under 37 C.F.R. §42.8(b)(1)

The real party-in-interest is Petitioner, Ford Motor Company.

B. Related Matters Under 37 C.F.R. §42.8(b)(2)

A claim of infringement of U.S. Patent No. 9,810,166 ("the '166 Patent") was asserted in *Ethanol Boosting Systems, LLC et al v. Ford Motor Company, LLC*, Case No. 1:19-cv-00196-CFC (Del. Dist. Ct.), filed on January 30, 2019.

Petitioner is simultaneously filing petitions for IPR of related U.S. Patent No. 8,069,839 under the case heading IPR2019-01400; U.S. Patent No. 9,255,519 under the case heading IPR2019-01401; and U.S. Patent No. 10,138,826 under the case heading IPR2019-01402.

The ’166 Patent recites that it is a continuation of U.S. patent application Ser. No. 14/982,086 filed on Dec. 29, 2015, which is now issued as U.S. Pat. No. 9,695,784, which is a continuation of U.S. patent application Ser. No. 14/478,069 filed on Sep. 5, 2014, which is now issued as U.S. Pat. No. 9,255,519, which is a continuation of U.S. patent application Ser. No. 14/249,806 filed on Apr. 10, 2014, which is now issued as U.S. Pat. No. 8,857,410, which is a continuation of U.S. patent application Ser. No. 13/956,498 filed on Aug. 1, 2013, which is now issued as U.S. Pat. No. 8,733,321, which is a continuation of U.S. patent application Ser. No. 13/629,836 filed on Sep. 28, 2012, which is now issued as U.S. Pat. No. 8,522,746, which is a continuation of U.S. patent application Ser. No. 13/368,382 filed on Feb. 8, 2012, which is now issued as U.S. Pat. No. 8,302,580, which is a continuation of U.S. patent application Ser. No. 13/282,787 filed Oct. 27, 2011, which is now issued as U.S. Pat. No. 8,146,568, which is a continuation of U.S. patent application Ser. No. 13/117,448 filed May 27, 2011, which is now issued as U.S. Pat. No. 8,069,839, which is a continuation of U.S. patent application Ser. No. 12/815,842, filed Jun. 15, 2010, which is now issued as U.S. Pat. No. 7,971,572, which is a continuation of U.S. patent application Ser. No. 12/329,729 filed on Dec. 8, 2008, which is now issued as U.S. Pat. No. 7,762,233, which is a continuation of U.S. patent application Ser. No. 11/840,719 filed on Aug. 17, 2007, which is now issued as U.S. Pat. No. 7,740,004, which is a continuation of U.S.

patent application Ser. No. 10/991,774, which is now issued as U.S. Pat. No. 7,314,033.

Petitioner is aware of two U.S. patent applications 16/251,658 and 16/424,471, which claim priority to the same application to which the ’166 Patent claims priority.

C. <u>Designation of Counsel Under 37 C.F.R. §42.8(b)(3)</u>

Petitioner provides the following designation of counsel.

Lead Counsel	Backup Counsel
Christopher TL Douglas Reg. No. 56,950 ALSTON & BIRD LLP 101 South Tryon Street, Suite 4000 Charlotte, NC 28280 Tel: 704.444.1000 Fax: 704.444.1111 Email: christopher.douglas@alston.com	Michael S. Connor Reg. No. 34,141 ALSTON & BIRD LLP 101 South Tryon Street, Suite 4000 Charlotte, NC 28280 Tel: 704.444.1000 Fax: 704.444.1111 Email: Ford-EBS@alston.com
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Pursuant to 37 C.F.R §42.10(b), a Power of Attorney is being submitted with this Petition.

D. Service Information

Please address all correspondence and service to the address listed above. Petitioner consents to electronic service directed to christopher.douglas@alston.com and Ford-EBS@alston.com.

Date: August 13, 2019

By: /Christopher TL Douglas/
Christopher TL Douglas

CERTIFICATION UNDER 37 C.F.R. §42.24

Under the provisions of 37 CFR §42.24, the undersigned hereby certifies that the word count for the foregoing Petition for *inter partes* review totals 13,994 words (Sections I-VIII), which is less than the 14,000 allowed under 37 CFR §42.24(a)(i).

Date: August 13, 2019

By: /Christopher TL Douglas/
Christopher TL Douglas

CERTIFICATE OF SERVICE

Pursuant to 37 C.F.R. §§42.6(e), 42.105, the undersigned hereby certifies service on the Patent Owner of a copy of this Petition and its respective exhibits to Patent Owner via UPS Next Day Air on the correspondence address of record for U.S. Patent No. 9,810,166 as follows:

MIT's Technology Licensing Office
255 Main Street NE 18-501
Cambridge MA 02142-1493

Petitioner also certifies that a courtesy copy of this Petition was sent via email to Patent Owner's litigation counsel:

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Date: August 13, 2019

By: /Christopher TL Douglas/
Christopher TL Douglas

EXHIBIT 10

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

ETHANOL BOOSTING SYSTEMS, LLC, and MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Plaintiffs, v. FORD MOTOR COMPANY, Defendant.	CA. No. 19-cv-196 CFC **JURY TRIAL DEMANDED**

DECLARATION OF DR. GREGORY M. SHAVER

1. My name is Dr. Gregory M. Shaver. I have been retained by Plaintiffs Ethanol Boosting Systems, LLC, and the Massachusetts Institute of Technology as an expert in this matter. I submit this declaration in support of Plaintiffs' Opening claim construction brief in this matter.

2. I earned my Bachelor of Science degree in Mechanical Engineering from Purdue University in 2000, graduating with highest distinction. In 2005, I earned my PhD in Mechanical Engineering from Stanford. Since 2006, I have been a been a professor of Mechanical Engineering at Purdue University, where I teach and conduct research in powertrain and engine control systems. I am currently managing a research group of 15 graduate students and 3 staff.

3. In addition to my teaching and research work at Purdue, I have worked as an expert in litigation matters relating to engine and powertrain controls, gasoline engine controls, and related tuning.

4. I have been asked by counsel to review the asserted patents and state my opinion as to the relevant standard of a person of ordinary skill in the art at the time of the invention. To that end, it is my opinion that a person of ordinary skill in the art would have a Bachelor of Science degree in Mechanical Engineering and 5 years of experience in engine controls and calibration, or equivalent education and experience.

5. I also have been asked by counsel to explain certain principles and concepts common to the operation of modern internal combustion engines and their associated fueling and control systems. Two such concepts are "open loop control" and "closed loop control," which typically are associated with a vehicle's fuel management system.

6. I also have been asked by counsel to review certain terms identified for construction by Defendant Ford Motor Company and to set forth my opinion, if any, as to whether such terms would be understood by a person of ordinary skill at the time of the invention to have an ordinary and customary meaning. To the extent Ford proposed a construction for a term, I likewise have been asked to offer my

opinion, if any, as to whether that constructions is consistent with how a person of ordinary skill at the time of the invention would understand the term.

7. "Open loop control" and "closed loop control" refer to two distinct forms of engine control systems.

8. "Open loop control" refers to a control system in which the control input is determined based on the desired value of the output that is controlled, as well as, prior knowledge of the relevant system. An example of such a system is the open-loop control of the fuel mass injected from a port fuel injector. Such a system does not use measurements or an estimation of the output that is controlled (the mass injection from the injector in the above example) to determine which controls inputs to provide.

9. In contrast, "closed loop control" refers to a control system in which the control input is determined based, at least in part, on a measurement or estimate of the output that is controlled. As a result, such systems sometimes are referred to informally as feedback systems. An example of such a feedback system is a knock detection or mitigation system. Such a system typically comprises at least a knock sensor, which is a senor that monitors structure-borne noise to detect for the occurrence of engine knock.

10. A fuel management system also can comprise both "open loop control" and "closed loop control." An example of open-loop control (injected fuel

mass from a particular port fuel injector) was given above. A typical example of closed-loop control in fuel management systems is the closed-loop control of exhaust lambda, via modulation of the overall fueling rate of the engine, as a means to keep the engine operating near stoichiometric conditions so that the three-way catalyst performs efficiently. This is closed-loop control because a measurement of the exhaust lambda (via one, or more, exhaust oxygen sensors) is used as part of the determination of control input (overall fueling rate of the engine) with the intent to control the exhaust lambda. In the example given, the setpoint for the overall fuel rate of the engine can be used to determine the desired injected fuel mass for each of the port fuel injectors. As such, in this example, you would have an open loop control system (for fuel mass injected from a particular port fuel injection) operating within a closed-loop system (for exhaust lambda).

11. "Torque" is a basic automotive term that would be understood by any person of ordinary skill at the time of the invention. It is a basic principle of mechanical engineering and a basic building block of automotive engines and most of their related systems.

12. In addition, I agree that "torque" can be calculated in a number of ways in addition to multiplying force and distance. Other non-limiting examples include (i) measuring electrical power E and speed of rotation N, and calculating torque as T = E/N; and (ii) measuring deformation of strain gages on a shaft, and

relating the measured, strain-induced-change in resistance to the torque. As such, I agree with Plaintiffs that the statement "Torque is calculated by multiplying force and distance" is incomplete. An accurate statement would be that torque can be calculated by multiplying force and distance.

13. "Load" also is a basic automotive term that would be understood by any person of ordinary skill at the time of the invention. It is understood to refer to the proportion of maximum torque at a particular engine speed that a particular engine is capable of outputting. For example, if a particular engine is capable of outputting 400 lb-ft (pound-feet) of torque at an engine speed of 1000 revolutions per minute and is outputting 400 lb-ft of torque at such engine speed, it is understood to be operating at 100% load. Similarly, if it was outputting only 300 lb-ft of torque at that engine speed, it would be understood to be operating at 75% load.

14. Notably, because maximum torque varies at different engines speeds, a person of ordinary skill in the art would understand that a particular engine's maximum or highest torque will vary depending on engine speed such that load varies depending on the engine speed.

October 9, 2019

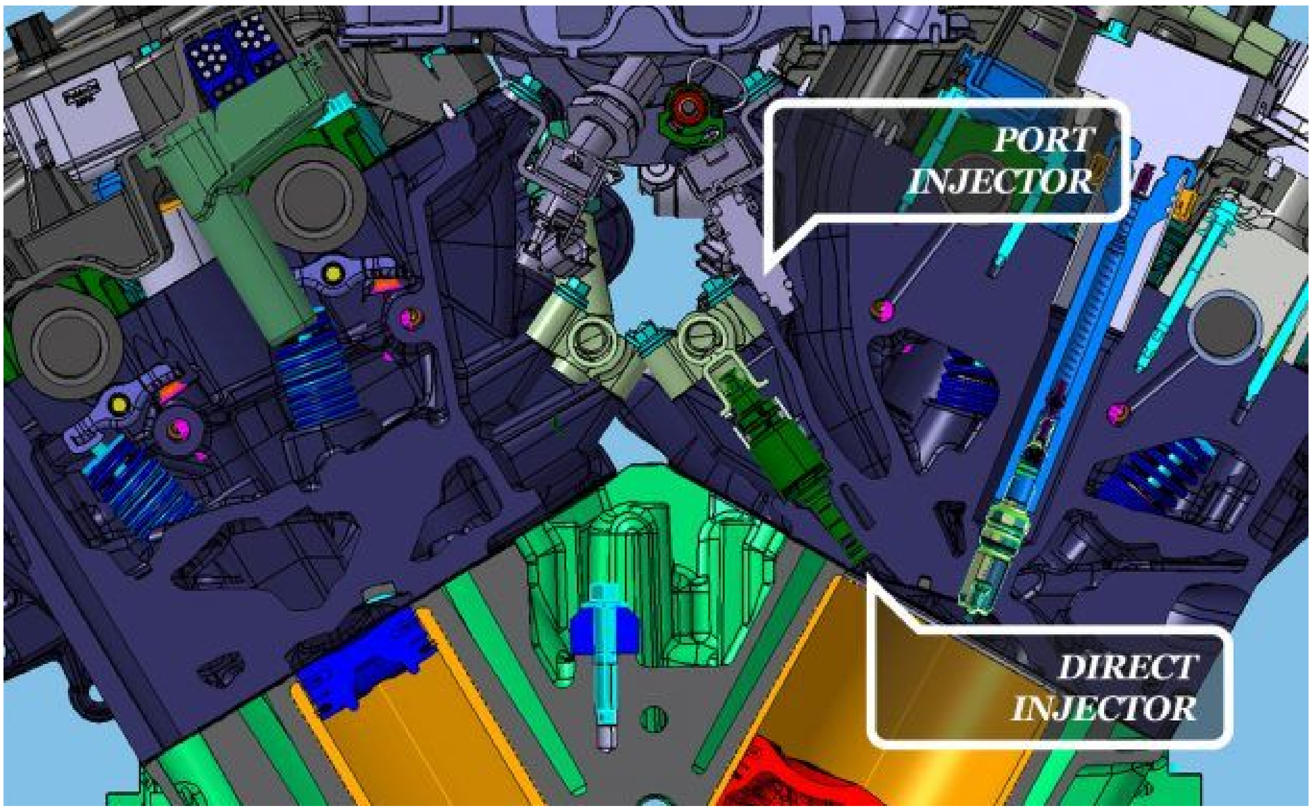
Dr. Gregory M. Shaver

EXHIBIT 11

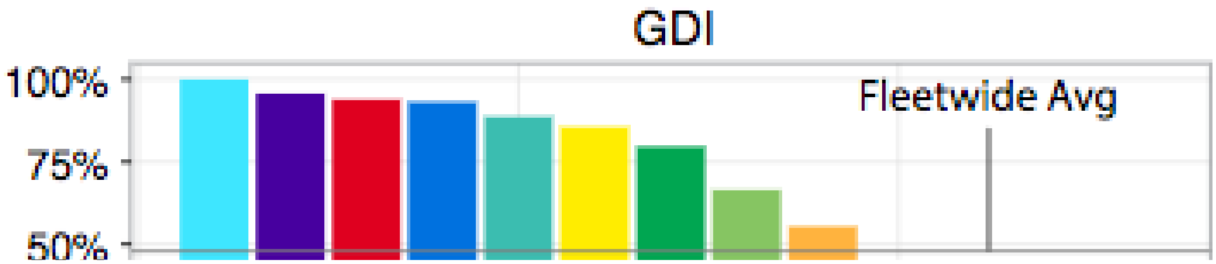
CAR AND DRIVER SUBSCRIBE

Explained: Why Some Engines Have Both Port and Direct Injection

DON SHERMAN MAY 2, 2017



Half of the U.S. new-car and truck fleet now is equipped with gasoline direct injection (also known as GDI)—which means the fuel is sprayed straight into the combustion chamber. This begs the question: What's the next engine innovation about to leave the lab?



The answer is bringing fuel to the fire by two separate paths, and a few makers already are fitting their engines with both port and direct injection. Toyota introduced this technology, which it calls D-4S injection, on a V-6 more than a decade ago and now uses port and direct injection on its 2.0-liter flat-four (which is built by Subaru), 3.5-liter V-6, and 5.0-liter V-8. Audi has it on its 3.0-liter V-6 and 5.2-liter V-10 engines.

Toyota's D-4S system was introduced on the 2006 Lexus IS350 3.5-liter V-6.

Ford currently is the dominant player with what it calls dual-fuel, high-pressure direct injection (DI) and lower-pressure port injection (PI). Applications include turbocharged and naturally aspirated V-6 and V-8 gasoline engines—four in all—ranging in size from 2.7 to 5.0 liters. The 2017 F-150 Raptor flying pickup and the GT supercar both are powered by new 3.5-liter EcoBoost V-6s so equipped. Ground-bound F-150s also rely heavily on this technology with a dual-fueled base 3.3-liter V-6 and optional EcoBoost 2.7- and 3.5-liter V-6s. Ford's most recently announced application thus far is the new 5.0-liter V-8 that will power the 2018 Mustang GT.

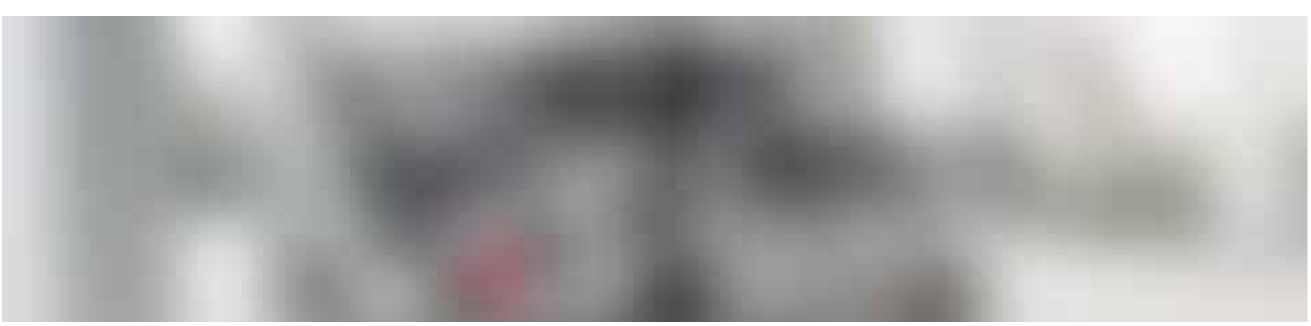
The Basics

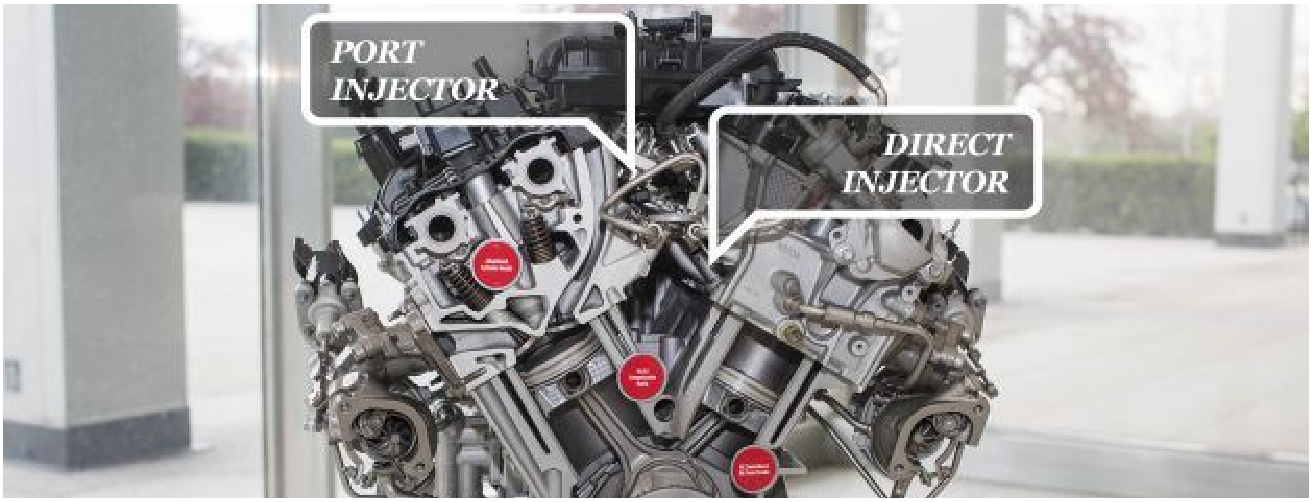
Before delving into the fine points of teaming PI with DI, a short primer is in order. Contrary to Hollywood's depictions of cars plummeting off cliffs, there is no such thing as spontaneous ignition. Because liquid gasoline won't burn, preparing fuel drawn from the tank to combust inside the engine is a two-step process.

Step one is atomizing the liquid to fine droplets, achieved by forcing gasoline pressurized by a pump through tiny injector orifices. A study by Hitachi engineers revealed that fuel pressurized to 1000 psi and injected through orifices ranging from 0.006 to 0.011 inch in diameter yielded a 135-mph mist of droplets only 0.000003 inch in diameter. That's fine.

Vaporization follows atomization. Here, the fine fuel droplets go through a liquid-to-gas phase change, becoming a vapor that can be mixed with air and ignited by the spark plug.

Because heat is absorbed during this phase change, there's a cooling effect, which can be used to improve the engine's operating efficiency. With PI, the air flowing through the intake manifold is cooled before it reaches the combustion chamber. With DI, the cooling benefit occurs within the chamber itself.





Ford equips several EcoBoost V-6 engines with dual injection, including its GT supercar.

Each strategy has pluses and minuses. PI is handy for naturally aspirated engines because cooling the incoming air increases its density and power-producing potential. It's significantly easier to locate injectors in the intake ports, well away from the valves and spark plugs. This upstream location provides ample time for full vaporization to occur. One downside is that fuel droplets sometimes are deposited on the intake port walls, upsetting the intended fuel-air ratio.

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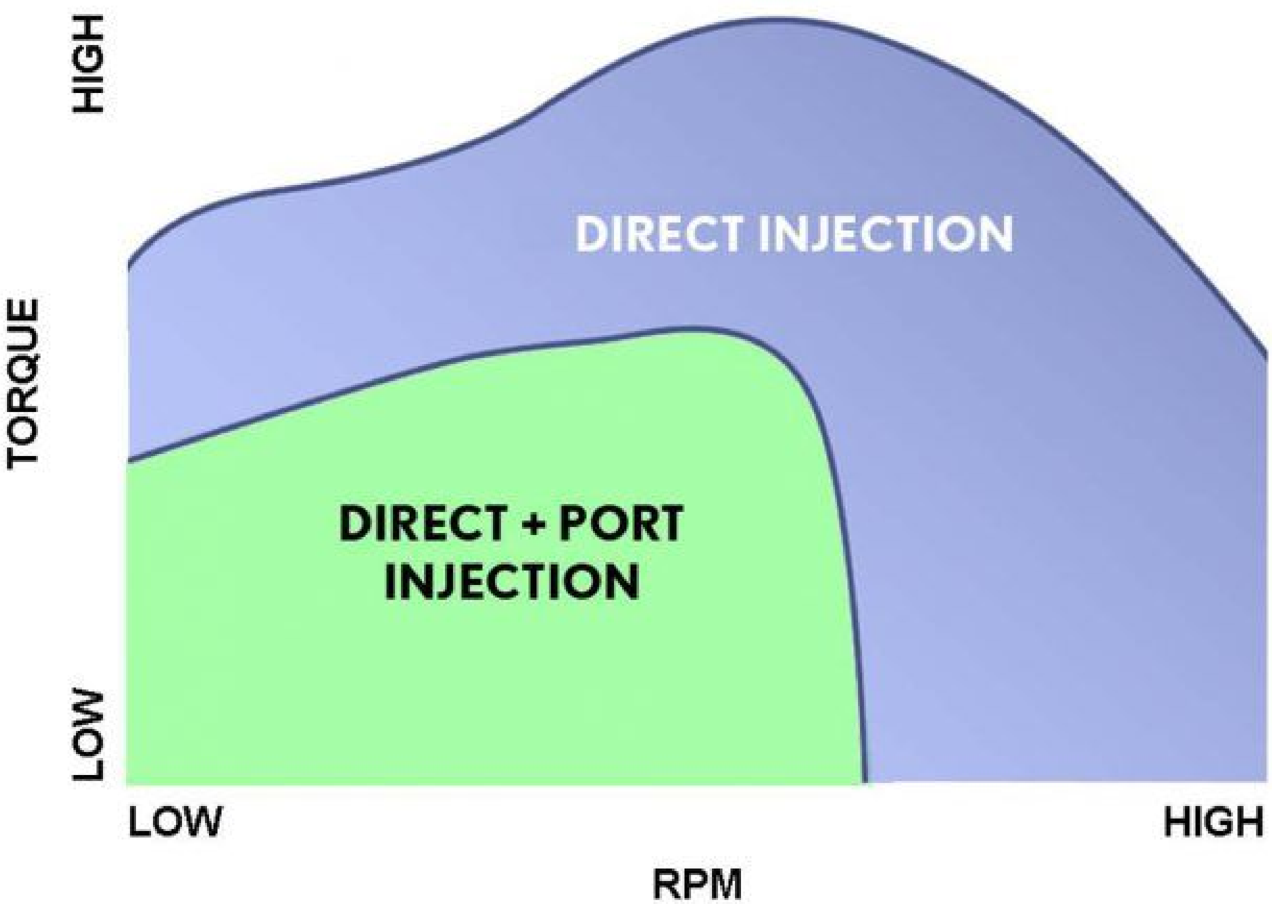
With DI, the chance of detonation—premature ignition of the fuel and air mixture—is diminished because the phase-change cooling effect takes place during the compression stroke just before ignition. Lowering the combustion chamber's surface temperatures enables a higher compression ratio and improved efficiency whether the engine is naturally aspirated or boosted. Ford raised peak torque by 30 lb-ft in its new 3.5-liter V-6 by combining the new dual-injection strategy with higher boost pressure.

There are downsides to DI. A DI system is more expensive because the pressure required to squirt fuel into the combustion chamber is 50 to 100 times higher than with PI, and the higher-pressure pump imposes parasitic losses. Direct injectors tend to be noisy. Carbon deposits—both on the backsides of the intake valves and on tailpipes—are service issues for some DI users. Because there's less time for vaporization to occur, some fuel escapes the combustion chamber and the catalytic converter as particulate matter or soot. These carbon particles are similar to but smaller in size than those spit out by diesel engines.

The Combination

The ultimate strategy is combining both PI and DI benefits, using each to diminish the other's negatives. Toyota, for example, fires both injectors during low to medium load and rpm conditions—in other words, during normal driving. This raises the density of the incoming charge without boosting and flushes carbon deposits off the intake valves. During high load and rpm circumstances, when maximum combustion chamber cooling is needed because detonation is more likely, DI handles all the fuel delivery.



Each maker uses a different strategy regarding when to use port, direct, or both injectors. One of Toyota's torque versus rpm versus injector use maps is shown here.

Peter Dowding, Ford's chief engineer of powertrain gasoline systems, revealed a different strategy. Ford uses PI alone at idle and at low rpm for smooth, quiet, and efficient engine operation. As rpm and load increase, fuel delivery becomes a programmed blend of PI and DI. In contrast to Toyota's methodology, Ford's PI is always operating, responsible for at least 5 to 10 percent of the fuel delivery.

Dowding and his Ford engineering colleague Stephen Russ stress that carbon deposits on tailpipes and intake valves have never been an issue in their DI engines. Dowding adds: "Now that electric motors are being assigned increasing propulsion roles, our task is to improve engine efficiency whenever we can. Ford's dual-fuel technology has already proven to be a valuable, cost-effective strategy in this effort."

- Explained: The Atkinson Combustion Cycle and Its Benefits
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- Watch Internal Combustion in Action with This See-Through Engine

Designing and developing modern engines is a juggling act that attempts to balance power, emissions, mileage, durability, drivability, and other concerns. The dual-fuel strategy gives engineers an additional key to turn as they strive to unlock more energy from each drop of gas. As lessons are learned and component costs fall, expect more makers to adopt this approach to fanning their fires.

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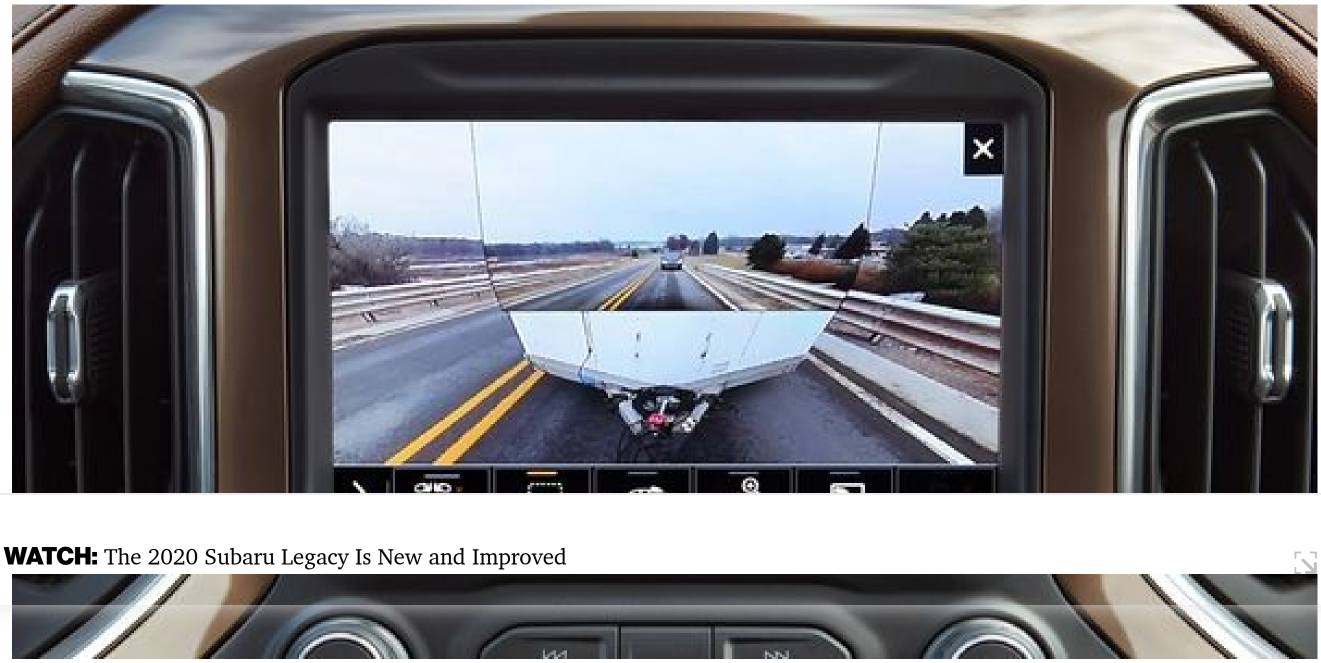

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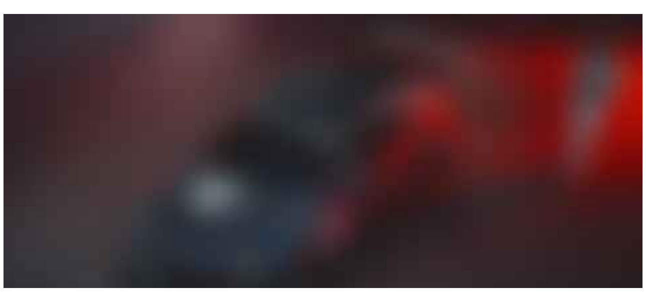

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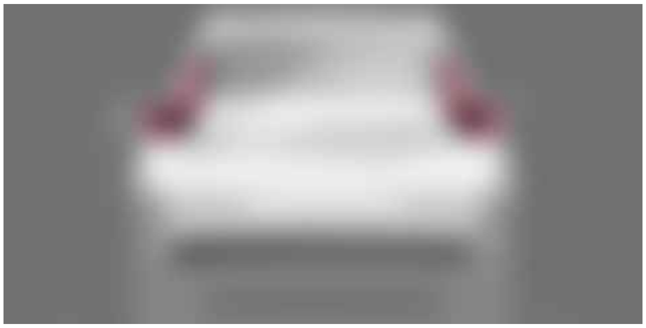

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EXHIBIT 12

Explore 2020 **F-150**

2020 Ford F-150

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The Ford F-150 features a high-strength, military-grade, aluminum-alloy body and high-strength steel frame, providing the foundation for available best-in-class* payload and up to 13,200 lbs. of available towing. The Ford F-150 makes tough tasks look easy, whether you're on the job or out on a weekend getaway.

*Max payload on F-150 XL Regular Cab, 8' box, 5.0L, 4x2, Heavy Duty Payload Pkg. Not shown. Class is Full-Size Pickups under 8,500 lbs. GVWR. See label on door jamb for carrying capacity of a specific vehicle. Max towing on F-150 XL SuperCrew®, 6.5' box, 3.5L EcoBoost®, 4x2 and Max Trailer Tow Pkg. Not shown. F-150 LARIAT, SuperCrew, 5.5' box, 4x4 shown. Max towing varies based on cargo, vehicle configuration, accessories and number of passengers. Towing and payload are independent attributes and may not be achieved simultaneously.

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TOUGH PERFORMANCE TO FOLLOW

Whether you drive an F-150 for work or recreation, F-150 offers a six-engine lineup delivering the performance you need. Naturally aspirated V8 gas powerplants with advanced twin independent variable cam timing. Turbocharged and port-fuel/direct-injected (PFDI) gas EcoBoost® V6 engines. And the 3.0L Power Stroke® Turbo Diesel.

Explore Power (/trucks/f150/2020/features/power/)

3.5L ECOBOOST®

375 horsepower and best-in-class* 470 lb.-ft of gas torque.

*When properly configured. Class is Full-Size Pickups under 8,500 lbs. GVWR.

1/3

360° Colorizer

2020 F-150

Exterior

Blue Jeans

Build & Price

F-150 RAPTOR. IT'S TIME FOR SOME SERIOUS OFF-ROADING.

Raptor is designed to deliver big-time capability off-road and turn heads on the road. It can tackle some of the most rugged terrains you want to take it on while looking good doing it.*

Explore Tough (/trucks/f150/2020/features/tough/)

*Always consult the Raptor supplement to the owner's manual before off-road driving, know your terrain and use appropriate safety gear.

3.5L TWIN-TURBO HO ECOBOOST®

The F-150 Raptor experience begins with its rugged suspension. To help power you through unforgiving terrain, it has a turbo HO 3.5L EcoBoost® with best-in-class* 450 horsepower and 510 lb.-ft. of torque.**

*Class is Full-Size Pickups under 8,500 lbs. GVWR.

**Horsepower and torque ratings based on premium fuel per SAE J1349® standard. Your results may vary.

1/3

FORD CO-PILOT360™ TECHNOLOGY

Ford Co-Pilot360™ Technologies can help you navigate crowded roads and highways with confidence.[10] *

*Feature availability varies by vehicle.

PRO TRAILER BACKUP ASSIST™ Bl

PRO TRAILER BACKUP ASSIST™

Whether you're a novice or a seasoned pro, backing up a trailer can be challenging. This available feature makes it as easy as turning a knob. Simply rotate in the direction you want the trailer to go and Pro Trailer Backup Assist responds accordingly.[10]

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F-150 Series and Appearance Packages

Toughness isn't the only feature that has made the Ford F-Series so popular. Out on the road, every F-150 stands out from the competition with its unique rugged style, which you can enhance with a custom appearance package.

Build & Price

STX APPEARANCE PACKAGE

Bold body-color accents and 20-inch wheels. Plus SYNC® 3 convenience and more.

1/8

STAY CONNECTED. ON THE JOB. ON THE WEEKEND.

Whether you're on the job or on a weekend getaway, Ford puts you quickly and easily in touch through in-vehicle touchscreen and voice-activated technology as well as smartphone apps. Connect with people, navigate to a destination, get useful trip information — just about anytime, anywhere.

AVAILABLE FORDPASS CONNECT™ WITH WI-FI HOTSPOT

AVAILABLE FORDPASS CONNECT™ WITH WI-FI HOTSPOT**

With FordPass Connect,™* drivers and passengers can enjoy an in-vehicle Wi-Fi hotspot powered by AT&T. Up to 10 devices can connect at once, and you can use FordPass™ to keep track of your Wi-Fi data usage. Also, you can access the hotspot from up to 50 feet away.

*FordPass Connect, (optional on select vehicles), (SYNC Connect for 2017/2018 model year vehicles), and FordPass Connect Service are required for remote features. (see FordPass Terms for details. Service for 2020 and later model year vehicles includes a complimentary 1-year trial for remote features, excluding Wi-Fi hotspot, and starts with vehicle sales date (after which, fees apply).

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2.
EPA-estimated city/hwy mpg for the model indicated. See fueleconomy.gov for fuel economy of other engine/transmission combinations. Actual mileage will vary. On plug-in hybrid models and electric models, fuel economy is stated in MPGe. MPGe is the EPA equivalent measure of gasoline fuel efficiency for electric mode operation.

3.
When properly equipped.

4.

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Classes are: Small Hybrid Vehicles (C-MAX Hybrid); Subcompact Cars (Fiesta); High-Performance Subcompact Cars (Fiesta ST); Small Sedans and Hatchbacks (Focus); High-Performance Small Cars (Focus ST); Small Electric Vehicles (Focus Electric); Midsize Sedans (Fusion); Midsize Hybrid Sedans (Fusion Hybrid); Midsize Plug-in Hybrid Sedans (Fusion Energi); Full-Size Sedans (Taurus); 300+ HP Sports Cars (Mustang); Small Utilities (Escape); Midsize Utilities (Edge); Large Utilities (Flex and Explorer); Extended Utilities (Expedition); Full-Size Pickups under 8,500 lbs. GVWR, Non-Hybrid (F-150); Full-Size Pickups over 8,500 lbs. GVWR (Super Duty); Full-Size Vans (Transit/E-Series); Small Cargo Vans (Transit Connect); 6-7 Classic Conventional Cabs (Medium Duty) based on Ford segmentation.

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Horsepower and torque ratings achieved with 93-octane fuel.

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EXHIBIT 13

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2017 Ford F-150 Raptor: 450 Horsepower and 510 lb.-ft of Torque | F-150 Raptor | Ford Performance

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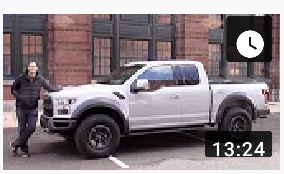

Here's Why the 2017 Ford F-150 Raptor Is Worth $65,000
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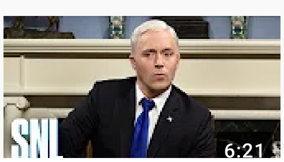

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